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The supply chain of Textile Upcycling -
A supply chain based analysis of challenges to industrially upcycling post-consumer textile waste

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List of Abbreviations

CLSCM	**Closed Loop Supply Chain Management**
Cp.	**Compare**
DIY	**Do-It-Yourself**
e.g.	**For example (exempli gratia)**
EU	**European Union**
i.e.	**That is to say (id est)**
ibid	**In the same place (ibidem)**
PCTW	**Post-consumer textile waste**
POE	**Point of Entry**
POR	**Point of Return**
POS	**Point of Sale**
Resp.	**Respectively**
SCM	**Supply Chain Management**
UK	**United Kingdom**
US	**United States of America**
WFD	**Waste Framework Directive**

1. Introduction

1.1. Problem statement

The textile industry is one of the most resource-intense industries worldwide. The production process is complex and requires huge amounts of water, energy, chemicals, and other resources. Owed to the high and continuously growing amounts of textiles produced globally each year, the huge negative environmental impacts are also on the rise, not yet speaking about the heavily criticized social conditions under which textile production partly takes place. The large amounts of waste that the production, selling and consumption of textiles generate, additionally add up to the environmental burden that the industry already places on our planet. Accelerating fashion cycles and decreasing useful life further amplify the problem (cp. Hawley 2009, p. 182).

The industrialised countries are the main consumers of textiles and garments in the world and with that, the largest producers of post-consumer textile waste (cp. Aus 2011, p. 55). Most of these countries have industrial textile recycling systems in place, that process enormous amounts of textile waste per year. In Germany alone, more than 800,000 tons of used textiles are collected by the textile recycling industry (cp. Löhr 2013). On average, about 50 % of the material is resold as sosecond hand products on domestic or international markets. However, for various reasons this fraction is continuously decreasing. The remaining, continuously increasing fraction is mainly downcycled to low-grade products like cleaning rags, insulation material or incinerated for energy production. Only a small share of this fraction actually makes it back into the fashion industry. From an economic and environmental perspective, large-scale downcycling is not acceptable: Elaborately produced products with a high environmental (maybe even social) footprint are processed to low-value applications whose market value in many cases does not even cover the costs of production. However, for a long time, the development of high-value, i.e. for example closed-loop recycling technologies, has been disregarded. The technologies available and market-ready today, require the entire deconstruction of fabrics and, specifically, often pure-fibre fabrics as an input material, in order to be able to produce same or similar quality levels as before. Hence, on a larger scale, recycling technologies available are not (yet) able to recycle the growing amounts of mixed-fibre fabrics to products of the same quality. Although science and industry have begun to tackle this issue within the last years, appropriate and alternative technologies for closed-loop recycling are only being developed now. However, even if these technologies will sometime soon deliver what they promise, as their processes are based on the complete deconstruction of a textile, they are very resource-intense. On top of that, as they only provide raw materials, textile production starts from the very beginning all-over again causing the same impacts on environment and people. As a result, the environmental or even financial benefits these technologies might be able to provide at some point in time, will be relatively low. As waste management in the European Union is covered by legislation in the field of environmental legislation, less resource-intense recycling processes, that are also suitable to create products of the same quality level, should be preferentially chosen.

Fashion upcycling represents an alternative, value-oriented and non-technical approach to recycling as it is practised today. It constitutes an attempt to prevent textile waste from being downcycled, incinerated or landfilled by using it as raw materials for the production of new, valuable textile products. This technique of product or fabric re-cycling does not dissolve the fabric's structure in contrast to all other closed-loop re-cycling[1] techniques. With this, the environmental footprint of recycled textiles can be drasti-

1 Concerning the definition of the term re-cycling see footnote 28 and 29.

cally lowered while at the same time processing costs can be saved.[2] Fashion upcycling uses the embedded value of fabrics and garments already produced. As a result, fashion upcycling is more environmentally sound than applying conventional recycling methods and offers the potential to significantly decrease the burden placed on our planet (cp. Aus 2011, p. 52).Most importantly, as upcycling works with given fabrics, it does not require purity of fibre or specific fibre compositions, nor does it require the exact knowledge about a fabric's composition. As a non-technical approach, fashion upcycling can basically process any type of textile waste, even damaged and stained fabric.

Up to now, however, fashion upcycling is mainly performed by independent designers and small labels who produce one-offs or small series, rather than large amounts on an industrial scale. Although their products help create awareness of the issue, the low volumes of production do not lead to significant environmental impacts and due to usually being premium price products, most of them are out of reach for the majority of consumers (cp. Aus 2011, p. 16). Another problem is that those labels which have tried to standardise and scale up production mainly use other types and sources of textile waste, rather than working with industrial recycling companies. This is due to the fact, that this type of material is generally linked to a number of disadvantages compared to production and pre-consumer waste. This particularly affects post-consumer textile waste that the textile recycling industry processes. As these represent by far the largest share of textile waste produced in industrialised countries, their use as raw material for industrial textile upcycling should be increased.

In order to promote the use of post-consumer textiles from industrial textile recycling as a raw material for industrial upcycling, this thesis models the supply chain of industrial upcycling, identifies differences i.e. disadvantages, compared to regular textile production, and identifies the challenges that are linked to industrially upcycling post-consumer textile waste from recycling (sorting) companies.

1.2. State of research and knowledge gap

Due to being a rather young and marginal concept of sustainable fashion design, upcycling has yet barely been discussed scientifically. More recent literature, both on sustainable fashion design and textile recycling, usually mentions and emphasises upcycling as one option for leading textile waste back into the economic cycle as valuable products with an environmental or even social value added (cp. e.g. Rouette 2006; Fletcher 2008; Sherburne 2009; Hawley 2009 and 2011 & Farrer 2011). However, up to now only few publications deal with the concept itself and the ones that exist primarily focus on the design process and the designer's role in upcycling:

Dunn (2008) developed an upcycling ethos and a design process for the "multiple production of one-offs" from PCTW that she acquired piece-wise through various channels in New Zealand. Dunn (cp. 2008, p. 92) concludes, that repeatability of designs is achievable on a larger scale of production with "more standardised raw materials" and names remainder stock as one suitable raw material type. Similarly, Fraser (2009) examines whether PCTW in New Zealand can be regarded an untapped commodity that could be redesigned and upcycled to standardised contemporary fashion. In her research, she uses a common type pair of male trousers as feedstock and develops a prototype. Emphasising on repeatability of the model, she finds that –from a designer and manufacturer's point of view– upcycling of PCTW offers the potential for producing standardised fashion products (cp. ibid., p. 54). Moreover, Fraser established a manufacturing process model for upcycling previously used

2 In her doctoral thesis, Aus compares environmental impact of upcycling a textile product finding that resources needed are minimal, and in case the purchase of an upcycled garment substitutes buying a conventional product can even be positive (cp. Aus 2011, p. 116).

garments (cp. ibid., p. 50). She identifies the feedstock's quality as well as the disassembling expertise as key parameters for successful upcycling of PCTW (cp. ibid.,p. 38, 48). In contrast to Dunn and Fraser who focused on post-consumer textiles only, in her doctoral thesis Aus (2011) experiments with all types of textile waste (production, pre-consumer and post-consumer waste). She evaluates their suitability for use as feedstock in textile upcycling in Estonia. Aus argues that, although feasible, post-consumer waste is not easy to use in serial and mass production, due to lack of availability in large quantities, insufficient quality and due to having a finished and used garment as a starting point material. Aus draws the conclusion that production waste is the most prospective source of textile waste for industrial upcycling in Estonia in terms of quality and quantity (cp. ibid., p. 50, 52).

All of the previously mentioned research papers confirm the possibility to upcycle PCTW in a standardized way. While the research of Dunn (2008) can be regarded as the pioneer work in that field, the work of Fraser (2009) represents an improved approach to upcycling PCTW due to only souring a certain type of garment, a strategy that (as will be seen in this paper) is also being followed in business practice today. Up to now, Aus' dissertation provides the most comprehensive analysis on the use of different types of textile waste in upcycling.

This thesis aims to identify the supply chain of upcycling post-consumer waste as well as issues related to serial or larger scale production based on the use of PCTW from industrial recycling companies. By looking at the challenges from a supply chain perspective, potential solution approaches are developed. Therefore, this thesis builds on each of the three papers in a different way, theoretically and practically:

- Fraser (2009) models the physical production process for upcycling a garment in a standardised procedure. This thesis amends this process by other value generating aspects to model the supply chain of industrial upcycling. As Fraser's approach of selecting a specific type of garment from the post-consumer waste stream for the purpose of upcycling is also applied in business practice, both her production process model as well as the supply chain model developed in this thesis are reviewed within the empirical inquiry as part of this thesis.
- Aus (2011) describes issues linked to upcycling different types of textile waste on a serial (mass) production scale and concludes that PCTW is rather more suitable for production of one-offs than industrial production. Although her conclusion is partly based on intrinsic characteristics of post-consumer waste material, her study has been carried out in the national context of Estonia, where there is no industrial textile recycling system that could provide large amounts of material (cp. ibid., p. 48).[3] This thesis uses Aus' insights on the issues of using PCTW in large-scale upcycling and – by means of an empirical study – compares them to the issues identified in upcycling practice. This enables a review of their validity in a context where industrial textile recycling systems are implemented and available, thus abstracting them from a case-related, local context. This differentiation enables the development of proposals for solution to supply-chain related issues in order to promote the utilisation and scaling-up of upcycling PCTW.
- Dunn (2008) and Aus (2011) both classify Upcycling as a concept based on the sustainability principle of eco-effectiveness, due to its design centricity. Within a critical discussion on the origins and the current upcycling practice, this assignment is reviewed resulting in a more grounded assignment of Upcycling as a concept of sustainable fashion design to one of the three sustainability principles (eco-efficiency, eco-effectiveness, sufficiency).

3 The same accounts for Dunn (2008) and Fraser (2009) whose studies both referred to the situation in New Zealand.

Furthermore both authors identify a number of upcycling techniques (cp. Dunn 2008) respectively forms of upcycling (cp. Aus 2011). As different forms of upcycling have not yet been classified in terms of the recycling strategy they follow, this thesis tries to close this gap.

The scientific value added by this master thesis comprises two levels. On a theoretical level, it comprises a grounding of the concept of Upcycling, as an approach to sustainable fashion design and a classification of different forms of textile upcycling. This is, however, not considered part of the research questions, but rather an additional task, which is necessary to analyse the approaches used in practice thoroughly and, on this basis, be able to develop supply chain based solutions or alternative business models for upcycling PCTW. Hence, this task is only indirectly part of the research questions. On a practical level, this thesis, on the one hand, reviews and complements the existing supply chain model, respectively production process model of industrial textile upcycling of PCTW, especially by integrating an economical perspective. On the other hand, supply chain based challenges in industrially upcycling post-consumer waste from textile recycling companies are identified and solutions to promote large scale PCTW upcycling are elaborated.

1.3. Proceeding

The aim of this master thesis is to identify challenges of industrially upcycling post-consumer textiles from industrial recycling companies and to outline solution approaches in order to promote the use of this type of waste in industrial upcycling. This requires answering the following questions:

1. *How is the supply chain of industrial upcycling of post-consumer textile waste organised and where does it differ from the production of virgin textiles?*

In order to answer this question, the supply chain of upcycling is modelled. The model is based on:

a) available literature on upcycling, i.e. mainly the manufacturing process model of Fraser (2009),
b) literature from the field of Supply Chain Management (SCM), i.e. Closed-loop Supply Chain Management (CLSCM) and Reverse Logistics, in order to identify common tasks in recycling which allows a higher degree of generalisation, and
c) literature on the supply chain of textile and garment production, in order to identify all other supply chain processes apart from physical production.

Following the "double-layer closed loop model" developed by Souren (2003), the model regards the necessary transformation processes and material flows in upcycling as well as relevant actors and transaction processes involved in order to compare both on differences to virgin textile production. Furthermore, crucial phases in the supply chain of upcycling are identified in order to reduce complexity and limit the identification of challenges to the most relevant phases. The empirical part of this research paper subsequently reviews and complements the model developed.

1. *What are the reasons that hinder industrial upcycling companies from using post-consumer textile waste as raw material for garment production, i.e. what challenges do industrial upcycling companies face due to the fact that they use post-consumer waste from recycling companies?*

The characteristics of the various types of textile waste influence the process of textile upcycling. Based on those properties and factors that generally influence recyclability, influencing factors for industrial upcyclability are identified. Referring to the crucial phases within the supply chain of upcycling, as modelled in question 1, i.e. potential issues in the supply chain of an industrial upcycling will be deduced and subsequently reviewed and complemented within the empirical part.

2. *What potential solution approaches could improve the co-operation between both companies?*

Based on the challenges identified, potential solutions to promote the use of PCTW from industrial textile recycling companies are proposed.

The paper is divided into eight chapters.
In Chapter 2, the concept of Supply Chain Management and particularly Closed-loop Supply Chain Management (CLSCM) is presented. Subsection 2.2.1. provides an orientation framework for closed-loop systems based on material flows, i.e. transformation processes as well as transactions, i.e. actors involved. In subsection 2.2.2.,different forms of closing product or material loops as well as factors influencing recyclability are described. Consequently, section 2.2.3. provides an overview on tasks related to recycling and based on this presents the "reverse" supply chain.
Chapter 3 depicts the supply chain of textiles. In section 3.1. the textile complex as the industrial surrounding is described. The supply chain of the textiles and garment industry is presented subsequently, in section 3.2. In order to provide an understanding of particularities of the textiles and garment industry and the relevance of textile re-and upcycling, section 3.3. briefly summarises the basic structure and characteristics of the sector as well as its economic, social and environmental impacts.
Whereas Chapter 3 discusses the phases of production and distribution within the life cycle of a textile(the "way there"), Chapter 4 deals with industrial textile recycling (the "way back"). In section 4.1. the terms recycling and textile recycling are defined. The different types of textile waste generated along the life cycle of a garment, and their basic characteristics are described in section 4.2. Section 4.3. presents the supply chain of industrial textile recycling, its products, negative and positive sustainability impacts. In that way, the "counter-concept" of upcycling and the prevailing pattern of how post-consumer textiles are dealt with today, its good and bad, can be depicted.
Chapter 5 introduces the concept of fashion upcycling. In section 5.1. the concept will be embedded into the broader context of sustainability by assigning it to one of the sustainability principles, i.e. eco-effectiveness. Section 5.2. and 5.3. illustrate upcycling in fashion design and the forms of fashion upcycling there are today, in more detail. In section 5.4. the supply chain model for industrial upcycling of post-consumer waste is finally developed. After identifying the crucial supply chain phases of upcycling, potential issues referring to those phases are deduced and described.
The methodology applied for conducting the empirical inquiry (expert interviews) and analysing the results (qualitative content analysis) is outlined in section 6.1. and 6.2. of Chapter 6. In section 6.3. the insights gained within the interviews are presented.

Chapter 7 critically reviews the proceeding in the thesis and provides scientific as well as practical implications based on the inquiry's results. In this context, approaches to solve the challenges of industrially upcycling post-consumer textiles are presented. Finally, in Chapter 8 the results are summarised and the research questions answered.

2. Supply Chain Management

Supply Chain Management (SCM) is an integrative and cooperative managerial concept that aims at aligning activities along the supply chain of a product in order to increase efficiency and maximize customer value. One specific form of SCM is Closed-loop Supply Chain Management (CLSCM) which takes a holistic view on supply chains and considers not only the "forward" but also the "reverse" streams. CLSCM and SCM function as the guiding (theoretical) framework to model the supply chain of industrial textile upcycling, identify influencing factors and challenges and elaborate proposals to promote the co-operation between industrial textile recyclers and upcyclers.
In section 2.1., the concept of SCM is generically described. Closed-loop Supply Chain Management which aims to create material cycles is described in section 2.2. In this context, the "double-layer closed loop model" is presented as well as different recycling processes and their dependency on a number of influencing factors. Eventually, activities in reverse supply chains are defined and a generic closed-loop or recycling supply chain is modelled.

2.1. Supply Chain Management and its characteristics

Supply chain management (SCM) is an integrative concept to align a company's internal activities optimally with the entire external value chain, that is to all suppliers, customers and disposal companies (cp. Goldbach 2003, p. 10). SCM is partly considered an extension of the value chain approach of Porter However, whereas the value chain (management) of a company considers the internal and external activities of value generation only, the supply chain (management) also focuses on aspects of supply, disposal and recycling (cp. Porter 2010, p. 60; Werner 2013, p. 17). Thus SCM looks at the physical availability, disposal, use and utilisation of goods as well as the respective flows of information and cash (cp. Werner 2013, p. 17).
Based on a comprehensive literature review, Glock (cp. 2009, p. 22-23)[4] identifies three characteristics of SCM that generically describe the concept and that can be applied to all kinds of supply chains:

1. Multifunctional orientation

Supply Chain Management comprises the management of material, information and financial streams, services as well as the disposal or backflow (i.e. recycling) of goods (cp. also Werner 2013, p. 17-18). This affects both the core functions of production like e.g. marketing, production or logistics (primary activities) as well as supporting activities in order to enable a frictionless process of rendering goods and services such as product development (secondary activities) (cp. also Porter 1999, p. 62). Following an integrative approach, SCM explicitly considers interdependencies/ cross-functional effects between the various functional areas and aims at aligning functions and processes.

2. Cross-company process integration

Usually the relevance of SCM is challenged with both a changing market environment as well as increased outsourcing of value generating processes. With respect to these changing conditions, a comprehensive coordination of

4 Cp. for the following paragraphs also the respective literature cited in Glock (2009, p. 22-23) in footnotes 133-144.

production processes is required, forcing companies to co-operate closely along the entire supply chain instead of limiting their focus on internal processes only.[5]

3. Customer orientation and strategic quality

The overall aim of SCM is to achieve a competitive advantage by providing customers with an added value over competing products. In the long run, this helps to retain existing customers and acquire new ones. Hence, all activities throughout the chain shall be downstream oriented towards the end user's needs (cp. Corsten & Gabriel 2002, p. 6-8). This might include e.g. the integration of product development into the chain (cp. Müller 2005, p. 2). As a result of continuous customer orientation, SCM gains a strategic quality as it is directly linked to the company's and the entire supply chain's performance.
SCM aims at maximizing efficiency and customer value along the supply chain of a product. The concept implies that only by means of co-operation, integration and down-stream orientation the maximum potential for optimization can be reached (cp. Corsten & Gabriel 2002, p. 4; Schulze 2007, p. 21). SCM tries to overcome functional limits of a company by coordinating and emphasizing inter-organizational relationships along the chain (cp. Otto & Kotzab 2003, p. 315; Schulze 2007, p. 21). However, concerning system boundaries, classic SCM rather only considers production and distribution, often sparing out consumption and the end-of-life (disposal) phase (cp. Dyckhoff, Souren & Keilen 2004, p. 17; Flapper, Van Nunen & Van Wassenhove 2005, p. 4). The concept of Closed-loop Supply Chain Management (CLSCM)[6], however, considers the entire life cycle of products and specifically aims at recycling products and materials.

2.2. Closed-loop Supply Chain Management (CLSCM)

The concept of Closed-loop Supply Chain Management (CLSCM) evolved from environmental management research on circulatory systems and the concept of SCM (cp. Guide & Van Wassenhove 2001, p. 9). CLSCM extends Supply Chain Management to all phases of a product's life cycle including the after-use or disposal phase of a product (cp. Morana 2005, p. 70). In contrast to SCM which aims at managing flows of resources effectively and efficiently along the supply chain, CLSCM furthermore aims at closing material cycles.[7] Material cycles can be closed on various levels: De Brito and Dekker (2004, p. 6; Fleischmann, Bloehmhof-Ruwaard, Dekker, Van der Laan, Van Nunen & Van Wassenhove 1997) distinguish between physical closed-loops where the product flows back to the original user and functional closed-loops where the product subsequently fulfils its original function/purpose. To them, closed-loop thinking emphasizes the coordination of forward and reverse flows, which is why they draw a clear distinction from waste management, as the latter only deals with reverse flows, i.e. a given input (cp. De Brito & Dekker 2004, p. 6).[8] Closed-loop supply chains can, but they don't have to be environmentally motivated, nor does their implementation have to be inter-

5 This integral perspective is often described by the metaphor of competing supply chains rather than competing companies (cp. also Corsten & Gabriel 2002, p. 4).

6 Dyckhoff et al. (2004) refer to Closed-loop Supply Chain Management as Closed Loop Management (CLM). The terms are used as synonyms (cp. Dyckhoff et al. 2004, p. 17; Morana 2005, p. 67). Here only the term Closed-loop Supply Chain Management will be used.

7 Material cycles for products are described as man-made (artificial), target-oriented systems in which products that can no longer be used for their initial purpose are physically fed back into production or consumption processes as an input factor (product, component or material level). This involves at least two actors (producer, consumer). (cp. Kirchgeorg 1999, p. 78).

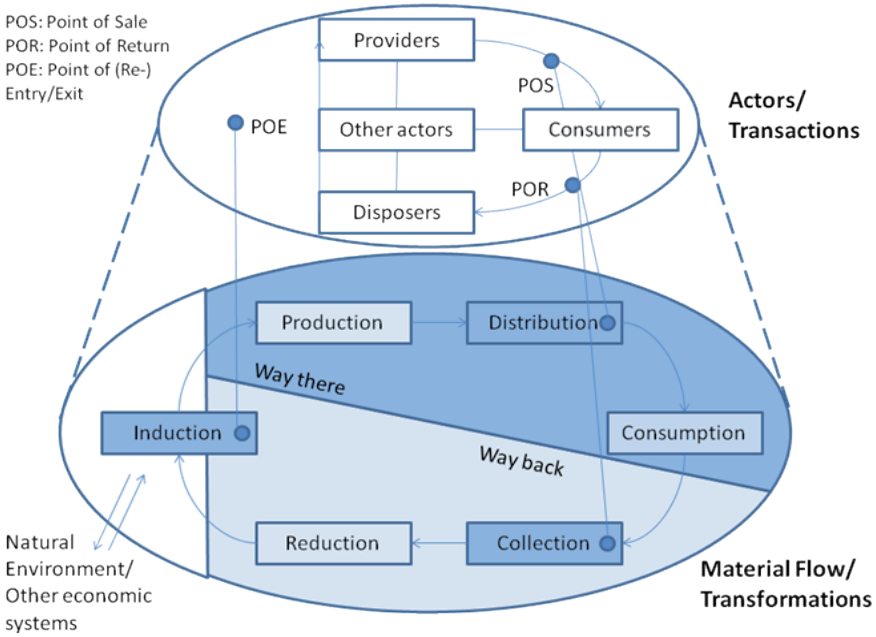
8 The authors distinguish closed loops from open loops. The latter they define as a material cycle in which neither the original user nor the original functionality is maintained (cp. De Brito & Dekker 2004, p. 6).

nally motivated. The implementation can be a legal requirement[9], economically rational due to direct and/or indirect gains[10] or pressure from competitors, or might even be demanded by stakeholders (cp. De Brito & Dekker 2004, p. 8-11; Flapper et al. 2005, p. 9-11).

2.2.1. *Processes and actors in closed-loop supply chains*

Souren (2003, p. 98) developed an orientation framework for closed-loop systems in order to describe relevant processes and actors: the "double-layer closed loop model". As shown in Figure 1, the model distinguishes actors and their relationships (transaction layer) as well as the material flows and processes needed to close the loop (transformation layer) (cp. Dyckhoff & Souren 2007, p. 55).

According to Dyckhoff et al. (cp. 2004, p 16-17) the lower layer depicts the material flows and distinguishes six phases of transformation: In the *production* phase, a product is manufactured using resources that either originate directly from the natural environment or indirectly as preliminary product from other economic supply chains. During *distribution* all products that are not directly used for production are made available to final customers. These use a product in the phase of *consumption*. In contrast to the previous phases where value has been added to the product, consumption usually decreases a product's value (deterioration) leading to its disposal when eventually classified as waste[11].



source: based on Dyckhoff et al. 2004, p. 17; Flapper et al. 2005, p. 5ff.

Fig. 1: Basic "double-layer closed loop model"

These three phases (the "way there") are usually considered in SCM and correspond with flow through systems. The consequent phases (the "way back") of collection, reduction and induction are elements of closed-loop or waste management systems only.[12] *Collection* describes the process of gathering and transporting waste to its conversion site. Optimally, the process of *reduction*– just like a production process– adds value to the waste material

9 Art. 8 (2) of the European Waste Framework Directive introduces the principle of extended producer responsibility that „may include an acceptance of returned products and the waste that remains after those products have been used as well as the subsequent management of the waste and financial responsibility for such activities".

10 Direct gains can result e.g. from decreasing need for raw materials or decreasing disposal costs. Indirect gains can comprise the anticipation or prohibition of legislation in this field, market protection, an improved supplier/customer relationship or a green image (cp. De Brito & Dekker 2004, p. 10-11).

11 Generally waste is not a purely objective term, it also comprises a subjective dimension depending on a system of values that attaches a positive, neutral, or negative utility to an object (cp. Gelbmann 2008, p. 98).

12 In waste management literature the processes are called differently: collection, waste utilization and disposal: waste utilization describes the various recycling strategies (re-use, further use, re-cycling and recovery) whereas disposal means discharge into the natural environment (e.g. land filling) (cp. Kranert & Cord-Landwehr 2010, p. 1-2).

turning it into a product again. It that case the secondary raw materials are allocated back into production during *induction phase*.[13] Otherwise the materials flow to other economic systems or the natural environment (cp. Dyckhoff & Souren 2007, p. 57).

The six phases of transformation of the "double layer closed loop model" depict different types of transformation processes. Whereas production, consumption and reduction are material transformation processes, distribution, collection and induction rather represent spatiotemporal transformations or transactions[14] (cp. Dyckhoff et al. 2004, p. 17; Morana 2005, p. 32-33). The latter are relevant as the material transformation processes are usually performed by different actors at various places and at different times (cp. Dyckhoff et al. 2004, p. 17). So, the upper layer of the model shows the various actors and their transactions. In complex product or material cycles there are four types of actors (cp. Dyckhoff et al. 2004, p. 18; Dyckhoff & Souren 2007, p. 58):

- *Providers*, e.g. producers, retailers, logistic service providers
- *Consumers*, households as well as public and private enterprises
- *Disposers*, public or private enterprises
- *Other actors*, e.g. the state, associations, system coordinators

Providers, *consumers* and *disposers* are directly involved in the material flow as they perform transformation processes. *Other actors* indirectly influence these processes by designing the legislative framework (state) or controlling/coordinating the recycling processes (system coordinators). De Brito and Dekker (cp. 2004, p. 19) also consider an actor's responsibility in closing the loop: Some might carry the responsibility (e.g. due to producer responsibility laws) while some of them might simply carry out tasks. Hence, the motivation and objectives to participate vary and might even compete.

While directly involved actors cannot be linked to a specific phase of transformation, the transaction points can: The *Point of Sale* (POS) is located in the phase of *Distribution* describing the transaction point between providers and consumers. The *Point of Return* (POR), where consumers pass control over objects to disposers, lies in the *Collection* phase. The *Point of (Re-) Entry* or *Exit* ,i.e. (POE) when disposers transmit the secondary material to providers or release it into the natural system, is situated in the phase of *Induction (*cp. Dyckhoff et al 2004, p. 18).

As the next section will show, supply chains can be closed at different stages of a product's life cycle applying different recycling processes. Hence, closing the loop does not have to involve all transformation processes and not all or even two actors.

2.2.2. Forms of recycling (closing the loop) and process influencing factors

In the phase of reduction, different types of recycling processes can be performed in order to lead a product or material back into production or consumption processes. Here De Brito and Dekker (cp. 2004, p. 17) distinguish different levels[15]:

- ***Product***: Either the entire product is reutilised as such, i.e. without being physically transformed (re-use, resale, further use), or the product is repaired beforehand.

13 The closing of material cycles using residues of production or consumption is called recycling (cp. e.g. Meffert & Kirchgeorg 1998, p. 370-372; Häberle 1997, p. 23).

14 A „transaction" can be defined as transferring control over an object from one actor to another (cp. Morana 2005, p. 32).

15 Thierry, Salomon, Van Nunen & Van Wassenhove (1995) directly distinguish between the categories of re-use, product recovery management (further use and re-cycling) and waste management (land filling and incineration).

- ***Component***: Products are dismantled and components are used for either producing the same or another product (remanufacturing), if needed new (virgin) components are added.
- ***Material***: The product is grinded and sorted into qualities and reused as raw material (recycling).
- ***Energy***: The product is burned for the purpose of retrieving embodied energy (incineration).

It is likely that, in case none of these processes apply, the product or material goes to landfill (cp. Goggin & Browne 2000 cited in De Brito & Dekker 2004, p. 9, 15-16).[16] Mentioned in that order the various options are 'more' to 'less' desirable, which is often depicted by a "inverted pyramid" similar to Lansink's waste hierarchy (prevention, reuse, recycling, disposal) (cp. De Brito & Dekker 2004, p. 16f.). It is often considered that the recycling processes at the top of the pyramid, especially re-use, create higher value and are more environmentally friendly than applying processes at the lower levels. De Brito and Dekker (cp. ibid., p. 17) stress that both is not necessarily the case as value generation also requires the existence of a market for the product and the (material) recycling process might consume more energy than the production of a new item.

The type of processing defines the product/material's later application. Whichever recycling process can be applied, depends in turn on a number of factors[17]:

1. **Product/material characteristics**: Intrinsic Factors (Composition), Use Pattern, Deterioration (cp. ibid., p. 17-19):

   A product's composition, that is the product design and whether it supports recovery, is essential, as composition and ease to recycle directly affect the economies of a recycling process. Factors of influence are e.g. the number of different materials used, their hazardousness and their heterogeneity[18] (cp. De Brito & Dekker 2004, p. 17).

   The pattern of use (location, intensity, duration) refers to the previous owner and affects for example collection. The infrastructure and effort needed to collect differs whether a user is an individual or an institution (bulk-use). Sourcing from private consumers demands collecting from a large number of locations for collection or might even require an effort from the user (bring systems). Time and intensity of consumption cause deterioration and therefore also affect recyclability. The life cycle phase in which the loop is closed, i.e. production, distribution, consumption and end-of-life, can be considered a helpful indicator for the pattern of use.[19]

   Deterioration characteristics refer to both the design of a product and its pattern of use. Deterioration leads to a product not functioning anymore, which might restrict applying certain recovery options. Factors of deterioration comprise aging (intrinsic deterioration), equality of aging of product

16 The waste hierarchy forms the principle of the EU's waste management policy, described in Art. 3 of Directive 2008/98/EC.

17 Fleischmann et al. (1997) distinguish between four categories: 1) the motivation (economical or environmental), 2) the type of item (packages, spare parts, consumer goods), 3) the form of reuse (direct reuse, repair, recycling, remanufacturing) and the processes (collection, testing, sorting, transportation and processing), and 4) the actors involved (parties of the forward channel or other, specialized parties) (cited in De Brito & Dekker 2004, p. 7f.).

18 This refers to the fact that homogeneous products are generally easier to recycle, as different materials might require the application of different recycling processes. Issues in recycling textiles arising from heterogeneous material compositions are described in chapter 4.3.2.

19 Material flows can either be closed during the process of production (e.g. recycling of production scrap or defectives), during the phase of distribution (e.g. commercial returns, recalls), or during consumption (e.g. warranties, repair, end-of-lease) respectively at the end of the consumption phase, i.e. at its „end-of-life" (cp. Flapper et al. 2005, p. 5). Accordingly there are different kinds of waste: production waste originates from the phase of production, pre-consumer waste is generated during distribution, and post-consumer waste is eventually produced by consumers (see section 4.3.).

components (homogeneity of deterioration) as well as the pace of fall in value (economic deterioration) due to technological improvements or fashion change.

Figure 2 shows how material characteristics and pattern of use influence a product's deterioration: The design and materials used to produce a product influence the speed of physical and economical deterioration. A low quality product for example deteriorates faster than a high quality product and fashionable products deteriorate faster in value perception than classic products. The consumer's pattern of use (intensity and duration) also influences physical deterioration.

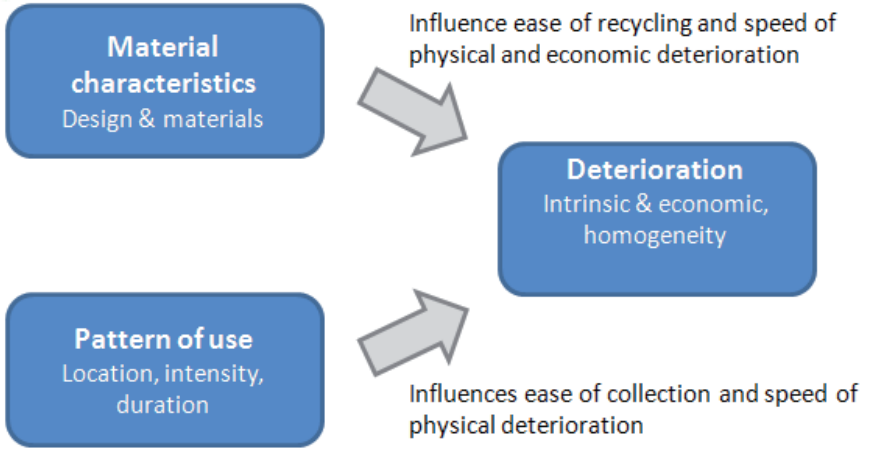


Fig. 2: Influence of material characteristics and pattern of use on deterioration

Whereas physical deterioration is only a question of design and use, economic deterioration also depends on extrinsic factors.

2. **Extrinsic factors**: Availability of collecting infrastructure, availability of technology, availability of a market/demand:
   For every individual product each of the three conditions has to be fulfilled to enable a recycling process to be performed at all. Dyckhoff et al. (cp. 2004, p. 20-21) call the lack of these enabling factors *functional-* respectively *institutional-based gaps*. An infrastructure for collection might be lacking entirely so there are no suppliers and no supply of material, or the backflow of material might be too low to process the items in a certain process or on scale. The missing of a technology indicates a reduction gap, i.e. if a transformation process for a product is not (yet) developed. Induction gaps are sales-related lacks, e.g. if a processing technology is too expensive to perform. Furthermore, reclaimed objects might not be competitive against primary ones, e.g. when the price difference between a recycled and a new product is too low compared to the recycling product's quality deviations. "Particularly low waste quality, disassembly problems and waste inhomogeneity often cause the above mentioned problems" (cp. Dyckhoff et al. 2004, p. 20-21).

Extrinsic factors represent requirements that have to be fulfilled, if waste is to be recycled. However, the characteristics of each product/material have to be assessed individually. They play a vital role as they determine how an item can be reutilised later on and how it has to be processed. The activities and tasks linked to closing the loop are described subsequently.

2.2.3. The reverse supply chain

Referring to the transformation level of the "double-layer closed loop model", the "way back" comprises a range of specific activities (cp. Dyckhoff et al. 2004, p. 17-18; Flapper et al. 2005, p. 11-13):

- Acquisition/collection of materials,
- Transportation to the places of processing,
- Testing, grading, sorting and storage[20],
- Processing, i.e. reuse, repair, recycling or disposal, depending on the variables described above, this might require cleaning, disassembly and reassembly,
- Distribution of the products

Based on these tasks a generic reverse supply chain could be depicted as follows:

Fig. 3: The reverse supply chain

Some activities might have to be performed manually (e.g. checking, grading) which is labour-intensive and costly. However, depending on the product/ material characteristics and the type of recycling process, the supply chain differs. With regard to the processing steps, some might not have to be performed at all, e.g. in the case of reuse. Management tasks at that level comprise the coordination of transportation and storage quantities, and, especially, the question which quantities should be set for collection and conversion of waste (cp. Dyckhoff et al. 2004, p. 16).

Tasks referring to the upper layer of the "double-layer closed loop model" deal with institutional transaction analysis based on marketing science and neo-institutional considerations. The motivation of actors to participate in closing the loop, the development of transactions (negotiations, contracting), and the incentive design to encourage consumer participation is of particular importance here.

Arrangements referring to both layers comprise mainly the question which actor should perform which of the transformations (make-or-buy decision). These institutional arrangements can be based on transaction cost theoretical considerations(cp. Dyckhoff et al. 2004, p. 16).

This chapter presented the concept of Supply Chain Management and particularly described closed loop supply chains. In general terms, SCM aims to align all activities along a product's value chains, CLSCM additionally aims to coordinate forward and reverse flows in order to create closed product or material loops. The creation of closed-loop or recycling systems is closely linked to the question of what products the waste can be turned into and therefore what recycling process can be applied. The creation of recycling systems depends on a number of intrinsic and extrinsic factors and the motivation of relevant actors to participate in closing the loop. Challenges that can arise due to the influence of these factors will be described in section 5.5. The upcycling supply chain, as it will be modelled in section 5.4., is partly based on the one hand on the reverse supply chain and its tasks as developed above.

3. The supply chain of textiles

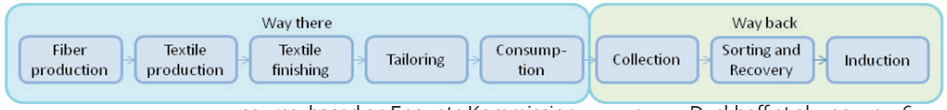
Modelling the upcycling supply chain and identifying potential challenges requires having a look at the entire supply chain of textiles. Upcycling brands operate in the same markets following the same rules like regular brands, hence it can be assumed that their supply chain does not fundamentally differ despite the fact that they use waste as raw materials. Section 3.1.presents the supply chain of textiles(the textile complex) in order to provide a holistic overview of the processes that take place along the life-cycle of textile products. Section

20 Checking and grading with subsequent sorting of every individual item could be required as products might have been used differently.

3.2.specifically deals with the supply chain of the garment industry. Finally, section 3.3. deals with the characteristics, i.e. the general structure and sustainability impacts of textile production and consumption(the "way there") today. The impacts of the "way back" will be discussed in chapter 4.

3.1. The Textile Complex

The textile complex is an industry perspective on the physical life-cycle of textiles. Figure 4 shows the major steps of value generation along the life-cycle of textile products. The steps are assigned to the "way there" or the "way back" as based on the "double-layer closed-loop model" (section 2.3.1.). The "way there" comprises the stages of production (production of fibres, yarn and fabric, textile dyeing and finishing, clothing production), distribution (selling and distribution) and the consumption phase. During consumption products are used, reused (by another person), laundered, and stored (cp. WRAP 2012, p. 3). The "way back" comprises the collection of textiles, their reduction (sorting[21] and respective recovery process (reuse, recycling, incineration, or disposal), and the induction phase where the reclaimed materials re-enter the economic respectively natural system (cp. Morana 2005, p. 114; WRAP 2012, p. 3).



source: based on Enquete Kommission 1994, p. 117; Dyckhoff et al. 2004, p. 16-17.

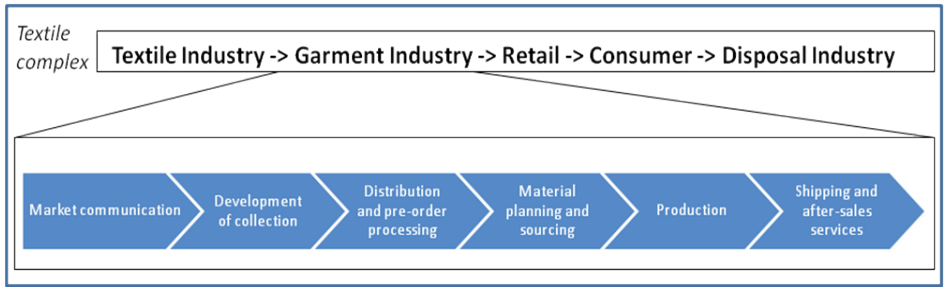
Fig. 4: The Textile Complex

Within the textile complex there are several other branches operating, one of which is the garment industry.

21 Sorting in textile recycling can be considered a reduction process as part of the sorted fractions directly reach end-of-waste status and can be resold as second-hand products without further transformation.

3.2. The supply chain of the garment industry

The garment industry performs specific tasks within the textile complex. Figure 5 shows the supply chain of the garment industry as part of the larger textile complex which comprises various industries respectively actors: the textile industry[22], the garment industry, retail, consumers, and the disposal companies, who eventually recover or dispose of items. The various phases within the garment supply chain (market communication, development of (seasonal) collection, distribution, and pre-order processing, material planning, and sourcing, production as well as shipping and after sales services) are briefly described subsequently.



based on: Grandke 1999, p. 68; Breitkopf 1999, p. 171.

Fig. 5: The garment value chain

Market communication is part of the market cultivation of a company. It comprises amongst others market research regarding colour, pattern, fabric, and other trends (cp. Grandke 1999, p. 79; Meadows 2010, p. 104). Market research provides information about developments within the upstream industries and future trends (cp. Ahlert, Heinemann & Große-Bölting 2009, p. 58).

22 Comprising the preliminary phases of clothing production, i.e. fibre, yarn and fabric production as well as textile finishing as shown in figure 4.

The information gained as well as the creativity of the designers, are important factors for the *design of a collection.* This stage covers collection planning (number of collections and models, thematic focus, prices, delivery dates), the design (models, colours, forms, patterns) including material purchase, final sample production as well as the technical realisation (sectional drawing, bill of materials) (cp. Altenhofen 1993, p. 36-38; Appelhans 2002, p. 26; Grandke 1999, p. 68-69; Meadows 2010, p. 106).

After sales samples have been produced, the collection is presented to retail (e.g. on fairs) and orders are received. This is covered within the *distribution* (order)phase about six to eight months before delivery (cp. Ahlert et al. 2009, p. 58). Thus, within the garment industry, marketing and sales take place directly after the collection has been designed, so production for retail is order-related (cp. Ahlert et al. 2009, p. 59). Building on the amount of orders, sales forecasts and projections are made, which are later used for the *planning of the production program* and the *sourcing of materials* (fabrics, linings, buttons, zippers, etc. (cp. Appelhans 2002, p. 26). Collection development and distribution build the core competences of a garment producer as both are eventually decisive in the company's performance.

The *sourcing* of fabric from the providing textile industry takes several months (2-3 on average) until the materials are delivered, hence the quantities needed have to be ordered on time (cp. Ahlert et al. 2009, p. 59; Appelhans 2002, p. 28). The disposition of materials and component parts commences during collection development or during the sales phase at the latest, so final disposition (order) can only be performed at order receipt (cp. Ahlert et al. 2009, p. 59f.). The material is stored at the respective supplier's until it is processed (ibid., p. 60).

The *production* process requires the preparation and management of production (when outsourced: choice of producers and preparation of technical documents) as well as the actual manufacturing of the garments (cp. Grandke 1999, p. 73f.). This comprises the folding and cutting of the fabrics, the sewing, and the finishing, i.e. ironing, final quality check, sewing in of brand and care labels (cp. Appelhans 2002, p. 28f.).

Shipping (logistics) covers storing, picking and packing and shipping of products to the various customers as well as order processing and *after-sales* services and support (cp. Grandke 1999, p. 81f.).

3.3. Characteristics and sustainability impacts of textile production and consumption

The supply chain of the textiles and garment industry is very complex in itself while involving a number of industries on top of the actual textile industry (e.g. agriculture, chemical and petro-chemical industry). Furthermore, the textile complex is largely globalized with strong international labour division between the various phases. Thus, it might well be that a piece of cloth has travelled more than 10,000 kilometres until it reaches the end user (cp. e.g. Farrer 2008). Garment manufacturing is a multilevel process that is chronologically determined (cp. Grandke 1999, p. 33). Although labour division is easy, garment and textile production is very labour-intense, especially the garment manufacturing (cutting, sewing, finishing), which is why premium producers make use of the global wage differentials, too (cp. Ahlert et al. 2009, p. 60). The fashion market is a buyer's market: it is fiercely competitive on the supply side and has to orient itself more and more towards customer wishes while producing a wide range of product variants. This goes hand in hand with the production pattern changing from production for stock[23] to commissioned production. Furthermore due to fast changing fashion trends

23 The production for stock has become rare due to the increased risk (cp. Ahlert et al. 2009, p. 59).

that heavily influence the industry, product life cycles as well as the lifespan of products have shortened. The number of collections per year has increased from formerly two to up to twelve collections including the offering of a permanent collection. These developments are consequences of what is called *fast fashion*, a business model that gains more and more ground within the industry and that is widely embraced by consumers (cp. Hawley 2011, p. 143).[24] Due to the acceleration, time pressure, and the pressure to innovate, a high degree of agility of the entire supply chain as well as comprehensive alignment of processes are required (cp. Morana 2005, p. 133). As a result, the value chain of garments is very instable, i.e. partners for production might change every season (cp. Schneidewind 2003, p. 28). This requires a very efficient organisation of transactions in order to decrease costs, but also shows that strategic relevance of the physical production process is low (cp. Grandke 1999, p. 75). The decisive supply chain phases for a fashion brand are the design and distribution phase. Another important success factor is the allocation of upstream products in the quantities and qualities needed at the right time.

Following the structure of the double-layer closed-loop model (section 2.2.1.), the sustainability[25] impacts of the textile complex can be easily linked to the "way there" and the "way back" (see Figure 4 in section 3.1.).In this section, the economic, environmental and social impacts of production, distribution and consumption will be briefly discussed. The sustainability impacts of the way back are dealt with in chapter 4.

The textiles and garments industry drives economies all over the world. In the year 2000 consumers spent about USD 1 trillion only in buying clothes, not to mention other kinds of textiles (cp. Aus 2011, p. 26). In 2006 the world trade in textiles and clothing amounted to USD 530 billion representing 7 % of exports The concept of fast fashion is based on consumption oriented production of cheap low-quality copies of high street fashion at a maximum speed and as cost-efficient as possible with the aim of high consumption and fast disposal and replacement (cp. Fletcher 2008, p. 163; Aus 2011, p. 26). worldwide (cp. WTO 2006; Allwood, Laursen, Malvido de Rodríguez & Bocken 2006). In China alone the sector employs more than 30 million people (cp. Farrer 2011, p. 24). During the last decades only, the amount of fibres produced increased significantly: Whereas in 1993 the fibre production worldwide amounted to some 40.1 million tons (cp. Eberle & Reichart 1996, p. 11), 16 years later, in 2009, it had increased by 75 % to more than 70 million tons (cp. Wollenschläger 2010, p. 38). However, as competition in the industry is fierce and so is pressure on costs, businesses cut costs or processes by using cheaper materials or outsourcing to countries where wages are lower and labour and environmental legislation is loose or not controlled for (cp. Sherburne 2009, p. 5). Apart from positive impacts (economic growth, jobs and income) that result from the textile industry's economical activities, there are a huge number of negative impacts attached: on the natural environment, the workforce, civil society and people's health.

In general the textile supply chain is very resource-intensive, it is characterized by labour-intensive processes, high material, water and energy turnovers, the utilization of plenty of problematic chemicals, and high amounts of waste produced along the entire chain (cp. Morana 2005, p. 143). Due to globalized supply chains, transportation between the various stages also has to be considered a significant

24 The concept of fast fashion is based on consumption oriented production of cheap low-quality copies of high street fashion at a maximum speed and as cost-efficient as possible with the aim of high consumption and fast disposal and replacement (cp. Fletcher 2008, p. 163; Aus 2011, p. 26).

25 Sustainability or sustainable development is a guiding concept that aims to „meet the needs of the present without compromising the ability of future generations to meet their own needs" (UN 1987, p. 15). The most common way of interpreting and operationalising the abstract idea of sustainability is the milking stool model in which sustainability represents the seat that is based on three legs that represent economy (profit), environment (planet), society (people) (cp. Farrer 2011, p. 20).

environmental impact (cp. ibid., p. 152). Environmental problems occur along the entire supply chain of textiles, beginning with resource extraction and ending with the disposal of textiles (cp. ibid., p. 143). The impacts affect all environmental media, soil, water and air, and also relate to health impacts, as harm to the environment can in turn cause harm to human health. Health problems or threats can, however, also result from insufficient health and safety measures at the various processing sites. Accompanied by other social issues in textile production referring to the field of human and labour rights, the major impacts on health, people, the environment and economy affect the "way there".[26] However, what is often underestimated in the discussion about the environmental consequences of textiles is the impacts of consumption: From a life cycle perspective the use phase has a considerable impact on the environmental performance of a textile, mainly due to use of detergents, energy, and water (cp. Morana 2005, p. 153). Up to 60% of the entire environmental impact can be traced back to this stage (cp. Minney 2008 cited in Aus 2011, p. 34). According to Dunn (cp. 2008, p. 25), "in historical and modern, affluent societies, whose consumption is based more on desire than on requirement, the material of clothing lasts much longer than the trend of fashion." So, consumers usually had only used their garments for about one third of their potential life time (cp. Eberle & Reichart 1996, p. 5).

The production of fast fashion items increases the negative impacts that the garment industry causes even more: their production consumes the same amount of resources needed for the production of any other textile. However, due to being designed for high consumption and short use times, the amount and speed of material flowing through the system are increased.

26 Morana (2005) and Fletcher (2008) provide a detailed and comprehensive overview on the environmental, social, and economical impacts of the textiles and garment industry.

4. Industrial Textile Recycling

Textile recycling in its various forms has been performed for a very long time already. Today, the reuse and recycling of textiles takes place on many societal levels: individually as a do-it-yourself concept at home, on swapping platforms or stylized to an event within so-called "swapping parties", through charity work of NGOs as well as by commercial organizations employing an entire industry (cp. Hawley 2000). It is the enormous amounts of textile products produced and discarded annually that enable the functioning of this branch. This chapter deals with the supply chain of textile recycling on an industrial scale. In section 4.1.the term recycling will be defined in its broad and narrow sense and applied to textiles. Section 4.2. describes the different types of textile waste and their characteristics. The typical supply chain of industrial textile recycling systems (the "way back") is presented in section 4.3. Textile recycling industries exist in many industrialised countries of the Western world where clothing is consumed and discarded in abundance. However, structures, supply chains, and recycling rates vary by country and from organisation to organisation. In the following, for reason of availability of data, it is the recycling system in the Unites Stated, the United Kingdom, Sweden, and Germany that will be referred to. The supply chain (collection and sorting) is basically the same in all of the countries mentioned, hence, it will be explained using the example of Germany. For this case, the literature provided the most detailed information. The description is amended by country-specific information from Sweden, the UK and the US wherever these diverge from the German example. The sustainability impacts along the reverse supply chain will also be considered in this context. As textiles are generally considered nearly 100% recyclable, section 4.4. will look at the technological, the economic and those issues that currently limit the closed-loop textile recycling, i.e. producing new textiles from textile waste.

4.1. Recycling

The term *textile* "covers all materials which are completely or mostly made from fibres or fur" (cp. Villanueva, Delgado, Luo, Eder, Catarino & Litten2010, p. 130). This comprises different more or less processed products within a broad range of purposes and applications, like textile fibres, semi-finished products (e.g. threads, yarns) as well as finished products like felts, fleeces or fabrics (cp. Eberle, Reichart 1996, p. 6). On the other hand "textiles" describes final product categories like clothing and shoes, home textiles (e.g. carpets), house textiles (curtains, towels, or bed linen) as well as technical textiles (cp. Villanueva et al. 2010, p. 130). In this thesis the term will refer to all kinds of fabrics and fabric products, but shoes and house textiles.

The term *recycling* has a broad and a narrow meaning. In its broader sense *recycling* describes a process in which residues of production or consumption are collected, sorted, if necessary treated and reused as recovered materials within production or consumption processes (cp. Häberle 1997, p. 23; Meffert, & Kirchgeorg 1998, p. 370-372). The aim of recycling is to implement man-made loops for the use of resources (cp. Häberle 1997, p. 23). Although Häberle speaks of "residues", being an instrument of waste management, the term *recycling* is generally only applied to what is considered *waste*.[27] So in its broader sense *recycling* means to collect, sort, and, if necessary, treat waste materials, in order to reuse them – in the same or another way– for production or consumption purposes, applying processes of product, component, material, or energy recycling (as presented in section 2.2.2.).

Another classification of processes is provided in the EU's Waste Framework Directive that distinguishes between *Preparation for Re-use*, *Recycling* and *Recovery*. Hence, this process of recycling (*re-cycling)*[28] that will be described below defines recycling in its narrow sense.

In scientific literature on recycling, the various processes can be classified according to the form or extent of processing (direct vs. indirect recycling) and the later purpose or use (primary vs. secondary recycling) of the recovered material (cp. Meffert & Kirchgeorg 1998, p. 371.). When materials are recycled directly they are reused or repaired keeping their form and composition (product recycling) whereas in indirect recycling they are deconstructed (component or material recycling, energy recovery).[29] "Primary" recycling refers to the secondary product or material fulfilling its prior purpose once more. When the material is intended for other purposes one talks about "secondary" recycling. According to this structure Häberle (cp. 1997, p. 27f.) distinguishes four different recycling purposes:

- **Re-use** means to keep on using the material for the same purpose (function) without any physical transformation of the object (form or material composition). Re-use is also considered *direct primary recycling*.
  This covers second hand use of textile products as they are, either when given to relatives or acquaintances, swapped[30], or when being resold e.g. in second hand shops, on flea markets, or online (cp. Fletcher 2008, p. 101;

27 According to Art. 3 (1) of the European Waste Framework Directive (WFD, official title: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives) textile products that are collected for recycling purposes, have become waste at the point in time where they are discarded. Art 3 of the WFD mentions different waste management strategies: Prevention, Preparation for Re-Use, Recycling, Recovery and Disposal. The first and the latter do not represent recycling strategies: When preventing, there is no waste to recycle, when disposing of waste, it is not lead back into the economic cycle (see also section 2.2.1.).

28 For sake of clarity the term will be spelled re-cycling. When the term is used in its broad (economic) sense the text will stick to „recycling".

29 Refer also to section 2.2.2. for different processes of closing the loop.

30 Swapping means to exchange clothes with other people. This might take place in the framework of a swapping party, or online, e.g. Swapstyle, www.swapstyle.com/about_us.php, 09/21/2013.

Müller, A. S. 2005, p. 92). However, it can only be assumed that the second hand material is really re-used, and not taken for any other than its initial purpose.

- **Further use** means that the object is not reused for its initial purpose, but maintains its original form and composition (*direct secondary recycling*).[31] Incorrectly, both in literature and on behalf of the recycling industry (cp. e.g. Morana 2005, p. 113; bvse 2010, p. 106), use as wipers is often considered an example of further use although the material is –at least on an industrial scale–changed in form through cutting and sewing. Another alleged example is using old clothes for garden works or carnival costumes (cp. Altenhövel 1999, p. 42) as the garments purpose does not change, it is still used as a garment. An actual example of further use is the use of a blanket as seat upholstery (cp. Müller, A. S. 2005, p. 101).
- **Re-cycling** means to reproduce the same product from the secondary material in a production process that includes (partial or full) decomposition of form and/or material composition (*indirect primary recycling*).
  As regards textile re-cycling, Eberle and Reichart (cp. 1996, p. 6) distinguish the re-cycling of fabric (components) and the re-cycling of fibres (material recycling). On fabric level, textiles are cut, or seams are opened, and the fabric is redesigned/reconstructed to a new product. This multilevel process is time-consuming and costly, but the aim is to provide the materials with a high value again. Mostly, this process is referred to as upgrading or upcycling.[32] Fibre re-cycling comprises the process of mechanical re-cycling, and raw material re-cycling physical and chemical recycling[33] with the intention to reproduce clothing or other high-value textiles.
- **Recovery** means processing secondary material within a different production process compared to the original one. Form and composition of the material is adapted to the needs of the new product (indirect secondary recycling).
  Examples of application for textile products that have been recovered comprise e.g. insulation material, upholstery or hat rags for the automotive industry, or park benches.

For environmental and economic reasons, direct forms of recycling are usually regarded as preferable to indirect recycling, due to making use of the maximum of embedded energy, while saving resources that would otherwise be needed for processing (cp. Fletcher 2008, p. 100; Sherburne 2009, p. 19; Hawley 2009, p. 183). The same applies to primary and secondary recycling: primary recycling results in a closed product loop, secondary material is usually used for less valuable applications as the examples have shown. Indirect recycling and secondary utilization are often connected to what is called *downcycling*, i.e. the utilization of recycled material on a lower quality level compared to the prior purpose[34] (cp. Wollny & Peter 1994; Diekenheuer & Hasselmann 1994). This logic is also reflected within the European Union's waste management approach, i.e. the WFD that applies to European industrial textile recycling companies. However, as stated in section 2.2.2. and as will be seen in section 4.3.2., following the waste hierarchy does not necessarily result in achieving the most economical, environmentally-friendly, and social solution.

31 In the Waste Framework Directive this category coincides with re-cycling.
32 The concept of upcycling will be dealt with in detail in chapter 5.
33 The processes are explained in section 4.3.2.
34 In this context, downcycling is understood as a secondary utilization that is not direct primary or indirect secondary recycling. Some examples of downcycling are mentioned above (e.g. insulation material, park benches).

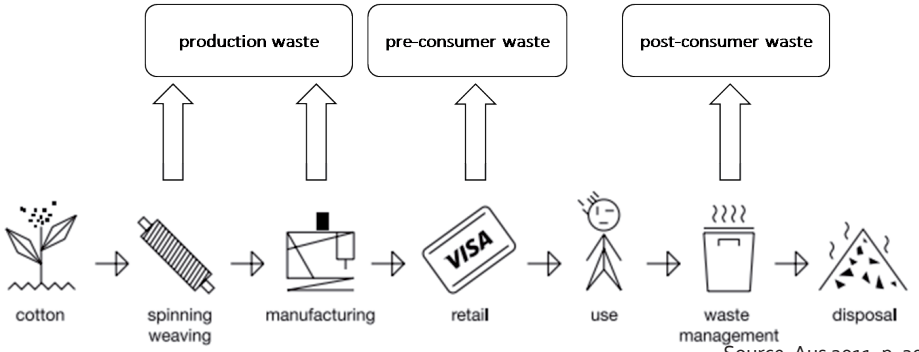
4.2. Types of textile waste

As all kinds of *waste* produced along the life cycle of a product are generally considered for recycling (cp. section 2.4.2.) and as the term *textiles* is applied to all sorts of unprocessed and processed fibre material, there are various types of textile waste. Usually, and especially in the context of textile recycling, one distinguishes between production waste, pre-consumer and post-consumer waste.

Production waste accumulates within the production process. In the textile value chain this can comprise: swatch samples (small textile samples), end-of-role textile waste (leftovers from garment manufacturing), cut-and-sew textile waste (scraps), sampling yardage waste (leftovers from textile sample production), damaged textile waste (unfinished textiles with colour or print defects) and sample clothing waste (part-finished or finished samples from design and production) (cp. Redress 2013b, p. 1f.).

Pre-consumer waste describes finished clothing waste, i.e. all sorts of sales leftovers from stores or product development, defective goods that have been returned as well as shipments that did not pass through customs (cp. Aus 2011, p. 49; Redress 2013b, p. 2). Pre-consumer waste is a phenomenon that has taken on unprecedented scale ever since the occurrence and diffusion of *fast fashion* (cp. Fletcher 2008, p. 163).[35]

Post-consumer textile waste is generated at the end of a textile's use phase (cp. Aus 2011, p. 48). The waste products would have reached the consumer, thus normally having been used or worn (cp. Farrer 2011, p. 35), but the material could also be dead stock. Post-consumer textile waste could for example be second hand clothing, curtains, sheets, blankets or table cloth (cp. Redress 2013b, p. 2). Another classification refers to the type of consumer, i.e. whether it is private households or public and private institutions to generate the textile waste. The latter produce textile and garment waste as bulk users, e.g. of corporate clothing, police and military uniforms (cp. Morley, Bartlett, McGill 2009, p. 60). Figure 9 provides an overview of the occurrence of the various types of textile waste in the life cycle of textiles.



Source: Aus 2011, p. 30

Fig. 6: Waste generation in the life-cycle of a textile product

As a result, the cycle can be closed at any of its various transformation phases: during production, distribution and consumption respectively at end-of-life. Whereas production waste from spinning can easily be recycled internally, all waste generated downstream usually requires the involvement of industry partners for recycling or disposal, due to the increasing complexity of the products (cp. Baur 1996, p. 22).[36] As a consequence recycling processes and disposal methods for

35 For the phenomenon of fast fashion see section 3.3.

36 The availability and proximity of options for discarding waste material, i.e. recycling companies, waste utilizations plants or landfills) are an important factor in this context. Their availability and proximity can be decisive for the subsequent direction of material flows (cp. Gelbmann 2010, p. 100).

the three fractions differ along the supply chain as well as locally.[37] Moreover, the three types of textile waste differ in characteristics due to their context of origin, which eventually also affects recyclability on an industrial scale. In this regard, production waste provides a range of advantages over pre- and post-consumer waste (cp. Aus 2011, p. 142). Production waste usually accumulates in equal intervals, in similar (or at least predictable) amounts, in larger volumes, in the same (one) place, and in the shape of the same materials, of which the composition is known (cp. Baur 1996, p. 8). Furthermore, the material is unused, thus there is no physical deterioration (see section 2.2.2.), and it is not as heavily processed as a finished jacket that has an upper material, lining, buttons, zipper, etc. (cp. Villanueva et al. 2010, p. 131): Production waste is only fabric material, whereas pre-consumer and post-consumer waste are both finished products. Pre-consumer waste is mainly sales leftovers or other dead stock, the material itself, the available amounts, the degree of deterioration (cleanliness and other flaws), and the degree of standardisation will vary from source to source and from season to season making it rather unpredictable. However, apart from stains and flaws, on average pre-consumer is not as deteriorated as post-consumer waste. Post-consumer waste from private households is usually unique pieces and therefore least standardised. This is different for institutional consumers that usually buy bulks of the same textile material (cp. Dunn 2008, p. 6). Post-consumer waste is usually used materials whose value has decreased within the process of consumption (apart from dead stock), although Hawley (cp. 2011, p. 147) points out that a lot of (private) donations still have price tags on.

Global figures on the production of textile waste are not available and on European level figures can only be estimated, as the statistical methods used are not yet harmonized entirely (cp. Villanueva et al. 2010, p. 78). However, even within the member states of the EU, figures are mostly based on estimations and partly have not been updated for years (e.g. Germany). For the year 2004 the amount of post-consumer textile waste[38] produced in the EU was estimated at nearly 5.8 million tons. This does not yet include production and pre-consumer waste and also excludes the amounts of "donated" textiles entering the textile recycling stream. Thus, the actual amounts of textiles and garments discarded must be considerably higher. Data on the quantities of the various types of textile waste are barely available in the case of production and pre-consumer waste. Only for Germany (outdated) figures on the amounts of production waste could be found: In 1996 production waste was estimated at 127,000 tons (cp. Müller, A. S. 2005, p. 55). As regards post-consumer waste, figures rather represent per capita estimations. The reason is that "textiles seldomly earn a category of their own in solid waste management data" (cp. Hawley 2011, p. 144). Moreover, the scope data referred to is not standardised and thus barely comparable. In the US more than 18 kg of fibre are discarded per capita per year (cp. Hawley 2009, p. 182). In the UK about 2.35 million tons of clothing and textile waste are produced annually which equals 40 kg per person per year (cp. Fletcher 2008, p. 98). For Germany, only figures on separately collected post-consumer textile waste (PCTW) are available, i.e. textiles that entered the household waste stream have not been captured. In 1996about 615,000 t of PCTW have been collected by the textile recycling industry (cp. Müller, A. S. 2005, p. 55), today it is an estimated amount of more than 750,000 t per year (cp. Siewert 2013, p. 93). Compared to the amount of production waste generated, there is a huge gap, which is very likely to have further increased due to a constantly shrinking German textile industry

37 In the US power plants do not support the incineration of textile waste which is why it is dumped on landfills (cp. Hawley 2009, p. 191).

38 In the European Union, according to Art. 3 (1) of the Waste Framework Directive, textiles become waste as soon as they are discarded, be it into the separate textile waste stream for the purpose of recycling or any other waste stream (e.g. household waste).

and increased amounts of post-consumer material collected. As outsourcing of production to low-wage countries has affected industrialised countries in general, the picture will be similar with post-consumer waste representing the largest share of textile waste produced in industrialised countries. Compared to the recycling of production waste, the recycling of PCTW is generally considered harder due to being finished, used and usually non-standardised products. The next section presents the supply chain and products of industrial textile recycling, which classically processes post-consumer textile waste.

4.3. The supply chain and products of industrial textile recycling

Considering the physical life cycle of textiles and garments as described in section 2.2., at the end of its use phase, a product is discarded and enters the waste stream (cp. Dyckhoff & Souren 2007, p. 57). In simplified terms, PCTW can either enter the household waste stream for the purpose of incineration or land filling, or be discarded into the (separated) textile waste stream for the purpose of re-use and recycling (cp. Rouette 2006, p. 938ff.). As described in section 2.2.1., the recycling process ("way back") comprises the phases of collection, reduction, and induction (cp. Dyckhoff et al. 2004, p. 16).

4.3.1. Collection

Generally, one can distinguish unseparated and separated collection schemes[39]: Unseparated collection schemes comprise disposal by means of domestic waste and bulk waste collection as well as recycling yards, whereas separate collection schemes comprise street and container collections, take-back via retail stores and other systems like direct receipt at clothing stores (cp. Morana 2005, p. 109ff.). In unseparated collection schemes material recycling is not possible respectively uneconomical, as the mixed waste would have to be sorted and cleaned first. As a result, it is either incinerated or dumped (cp. Bilitewski & Härdtle 2013, p. 6). In many European countries and the US, there are separate collection schemes for post-consumer textiles that only enable product and material recycling. In Germany for instance, this comprise street and container collections as well as take-back via retail or direct receipt in second hand or clothing stores (cp. Morana 2005a, p. 30; Eberle & Reichart 1996, p. 17).

Although there are producer initiated take-back systems via retail stores, the collection of post-consumer textiles is mainly carried out by either commercial textile recycling companies (state-owned or private-sector companies) or charitable organizations, sometimes in co-operation with one another (cp. Morana 2005, p. 29; Hawley 2011, p. 184). The quality and condition of collected goods directly affect the recycling process, hence recycling companies are required to carefully handle the textiles in order to secure the material's value (cp. Morana 2005, p. 111). As textiles are shopping goods that are not disposed of regularly, the material flow to the recycling company is subject to variation, neither amounts nor disposal time can be planned by the recycling company (cp. ibid., p. 111-112).

Figures on the amount of textiles collected for the purpose of recycling are partly not available or vary due to the nationally differing recycling systems and collection channels. In the US, textile recycling companies collect about 1.1 million tons per year (cp. Hawley 2009, p. 182). In Germany more than 750,000 t are collected annually (cp. Siewert 2013, p. 93).[40]

39 Another way to classify collection schemes is depending on whether the textiles are being picked-up from the households, or whether they have to be brought to special places or premises. The first are known as curbside systems, e.g. collection of household waste, bulky waste and the traditional street collection of textiles. The latter are known as bring systems made available for public use like e.g. containers for used textiles, recycling yards or take-back in shops (cp. Dönnebrink 1998, p. 71; Morana 2005, p. 111).

40 Löhr (2013) speaks of 830,000 t of used textiles collected in Germany each year.

Although the amounts of textiles that industrial recycling systems collect and process are huge, an estimated share of more than 50 % of textiles discarded enters unseparated collection schemes that do not allow material recycling.[41]

4.3.2. Reduction and induction

The reduction process is crucial, as it usually adds value to the waste material, turning it into a product again. Reduction comprises sorting, the actual recycling process and the re-entry into the economic system. In the case of second hand textiles the phases of reduction and induction only comprise sorting, pressing, and packing of the material. Afterwards they are stored or directly resold (cp. Müller, A. S. 2005; 172). All other fractions that the sorting process produces first have to undergo a more or less extensive re-cycling or recovery process before they can be utilized again.

4.3.2.1. Sorting

After the textiles are collected they are transported to a sorting facility, where they are sorted into various fractions according to the waste hierarchy (as described in section 4.1.), oriented towards the later application. Common secondary applications are second hand textiles, wipers, and secondary raw materials. Fractions for which no material recycling is possible are either incinerated for energy production or land filled (cp. bvse 2010, p. 106; Fletcher 208: 99; Hawley 2009, p. 187). In Sweden they are only sorted according to them being either rewearable and non-rewearable textiles, as there is no re-cycling industry that could produce other products such as wipers (cp. Palm 2011, p. 12).

The aim of the sorting process is to reclaim as many second-hand textiles as possible due to their high value and resale price, and to produce as little waste for disposal as possible (cp. Müller, A. S. 2005, p. 96). Thus, sorting is the central value creation process in textile recycling. It is oriented towards qualitative aspects, which is why it has to be performed manually, thus making it costly. The material is sorted according to condition, product groups (e.g. pullovers), aspects of fashion, the later sales market, the potential utilisation of the material (e.g. for use as wipers), as well as colour, fibre type resp. material composition (cp. Morana 2005: 112; Baur 1996: 26; Hawley 2009, p. 186).[42] The process can be divided into four resp. three stages of production (cp. Müller, A. S. 2005, p. 96-97; Strobusch & Terpinc 1995, p. 26):

1. rough sorting,
2. pre-sorting (sometimes comprises rough sorting),
3. fine sorting, and
4. special sorting.

In stage I, the material is roughly sorted removing all non-textile material that people dispose of with their used textiles, e.g. toys, household items or residual waste are removed (cp. Strobusch & Terpinc 1995,p. 26). Rough sorting can also be done simultaneously with pre-sorting (stage II). The textiles are sorted according to a number of product categories and later use (shoes, garments,

41 The figure refers to a German study by from 1996 (cp. Dönnebrink 1996). In the UK and the US less than 30 % are reclaimed (cp. Fletcher 2008, p. 98; Hawley 2009, p. 182). Reasons are, on the one hand, that some groups of textile products are (for various reasons) preferably discarded into household waste, like e.g. underwear and socks, or technical textiles (cp. Müller A. S. 2005; 92).

42 Further sorting criteria comprise among others degree of deterioration (wear, staining, signs of usage, defects), quality of processing, sizes and seasons. The reduction process is crucial in this process, as it usually adds value to the waste material, turning it into a product again (Müller, A. S. 2005, p. 222).

accessories, wipers, material for reprocessing (cotton, wool, etc.)). The amount of categories in pre-sorting varies between 12 and 20 (cp. Müller, A. S. 2005, p. 97). Subsequently, during fine sorting, the textiles within each product category are sorted more accurately, which leads to differentiated products that can be sold to the company's standard markets, e.g. Eastern Europe or Africa. In the case of wipers and secondary raw material it is sorted according to e.g. colour, material composition, or type of fabric (knitted, woven, etc.). After fine sorting (stage II resp. III) the material has been divided into about 60-80 fractions. In production stage III (IV) the textiles for second hand use are sorted according to the specific needs of the customer taking account of climatic, cultural, religious, and fashion aspects. This kind of sorting is performed on request. In practice, sorting companies partly consider up to 400 criteria (cp. ibid, p. 97-98).[43]

According to the German textile recycling industry about 90 % of the collected material can be used in some way. The figures on re-use and re-cycling partly vary significantly. On average the process generates the following products (cp. bvse 2010, p. 106):

- 43 % re-useable textiles that are sold as second hand products
- 16 % textiles for use as wipers
- 21 % for use as secondary raw material
- 10 % for energy production (incineration)
- 10 % waste

The large fraction destined for second hand use is divided into four qualities: the high-quality, well-preserved "creme ware"[44] (1-3 %) which can be resold on domestic markets, No 1 quality (4 %), No 2 quality (38 %) and No 3 quality (3,5 %) which are exported to other European, African and Asian countries (Müller, A. S. 2005, p. 97).[45] The second hand products can be shipped to the particular customer after being pressed into bales, and wrapped up in protection foil (cp. Strobusch & Terpinc 1995, p. 27).

Second hand reuse represents the most profitable product category for textile recycling companies, hence they try to reuse as much material as possible. The various second hand fractions are the main source of turnover and profit to a textile recycling company, especially high-value clothes in good condition, like e.g. brand-name or vintage clothes. However, with fast fashion gaining more and more ground, also the value and resale price of post-consumer textile waste decreases due to the decreasing quality of textiles (cp. Black 2008, p. 191; Fletcher 2008, p. 106). This does not only affect second hand resale prices, but also the value of all other fractions and with this the economics of industrial textile recycling in general (cp. Hütz-Adams 2005, p. 2). As a result, the share of second hand textiles continuously decreases and more and more products have to be downcycled.

Environmentally speaking, second hand use is also advantageous over other recycling techniques: Apart from energy costs for collection, sorting, and later

43 The number of criteria varies from company to company, and in particular with company size. In textile recycling literature numbers vary between 120 (cp. Baur 1996, p. 26; Rouette 2003, p. 941) and 400 criteria (cp. Müller 2005, p. 97). Müller (2005a,p. 222) provides a comprehensive overview on the sorting criteria.

44 In the US this category is called „diamonds" (Hawley 2009, p. 191).

45 The number of categories and the percentages can differ among textile recycling companies and by country. In the US the re-use fraction also represents the largest share with about 50 % of which 48 % are second hand clothes destined for export and 1-2 % for use as „diamonds" (Hawley 2011, p. 187, 191). About one third (29 %) are processed to secondary raw materials, 17 % are used as wiping and polishing cloths and less than 7 % are incinerated or dumped on landfills (cp. ibid.,p. 189-191). In Sweden a total of 22,000 t could be reused in 2008 (cp. Palm 2011,p. 11).

transport, no other negative environmental impacts occur in the first place which means that the efficiency in use of the product's embedded energy[46] has been maximized (cp. Fletcher 2008, p. 100). Second hand reuse saves 10-20 times the energy needed to produce a new garment, not yet considering the need for water and chemicals in textile production (cp. ibid.). Currently, about 50 % of discarded post-consumer textiles can be reused, the largest fraction of which is exported to developing countries, where they dress the majority of people due to their low price and where second hand textiles maintain a business sector that employs millions of people (cp. Sherborne 2009, p. 5). On the other hand this practice is said to have destroyed local textile industries that could not compete with the cheap imports of second hand products and thus creates dependency (cp. Hütz-Adams 1995, p. 103). Clearly, the international trade in used textiles shifts the responsibility of waste handling to the importing countries that often do not have waste management systems installed that can compare with the standards in industrialised countries. This can lead to the goods being eventually dumped or incinerated in an uncontrolled manner. As regards health impacts, using second hand textiles minimises the risk for allergic reaction, as remnants of chemicals used during production have already been removed by laundering (cp. Müller, A. S. 2005, p. 101).

4.3.2.2. Re-cycling

Currently about 50% of the collected textiles cannot be re-used as second hand products due to being damaged, heavily dirty, of poor quality, out-grown or out-of-fashion (cp. Hawley 2009, p. 183). The vast majority of this fraction will not be recycled to garments or other high-quality (textile) products (primary recycling), but downcycled to wipers, bath rugs, non-woven fabrics (e.g. insulation material), or used as a fuel for energy production (cp. Siewert 2013, p. 93; Rouette 2006, p. 940-941; Hawley 2011, p. 189-190).

Textiles for use as wipers (16-17 %) are cut, sewn and resold as disposable or reusable wipers e.g. to the automotive industry. Textiles suitable for this application mainly consist of cotton, viscose or other absorbent fibres. Recycling to wipers is not a form of "further use", it is a form of material re-cycling (cp. Müller, A. S. 2005, p. 106). Wiper production provides a useful purpose for certain types of textile waste and therefore saves natural resources for the production of new wipers. Although wiper production is a simple process, in many cases the prices that can be achieved on the market do not cover the costs of collection, sorting and processing (cp. ibid., p. 102).

If a textile re-cycling industry is in place, textiles destined for use as secondary raw material (21-29 %) can be used for a variety of applications. Three re-cycling processes can be distinguished: mechanical, physical, and chemical recycling:

- *Mechanical recycling* is the oldest of the three techniques. The fabric is torn apart using carding machines (cp. Fletcher 2008, p. 103). Due to the mechanical stress fibres are shortened and therefore suffer a quality decrease (ibid.). Mechanical recycling is generally suitable for natural, synthetic and mixed fibres (cp. Baur 1996, p. 30). Under certain conditions[47] mechanically recycled fibre material can be spun to yarn again for use in woven textile products, among others garments. In order to improve the quality of the product, virgin fibres can be added. However, demand on behalf of the textile and garment industry for mechanically recycled fibres is low, especially for post-consumer material, as processing a finished

46 „Embedded energy means all the resources and energy used in the production of the garment. This includes that used in growing and harvesting and other synthetic fibre production, then spinning, weaving, knitting, sewing, finishing, including the production chains of zips, buttons, threads, beads, and decorative embellishments" (Sherburne 2009, p. 19).

47 The major condition is purity of fibre.

garment is more elaborate and complex and unknown fibre mixtures and predefined colours make the results of the process less predictable. Particularly production waste is advantageous in this case, as it comes in batches of same fabric and colour and the material composition is usually known. According to Fletcher (2008: 105) yarns and fabrics from mechanical recycling (thus primary recycling) remain a niche market, and are not easy to source. Mechanically recycled fibres are mainly used for secondary purposes and non-woven applications. These comprise fleece production for heat and acoustic insulation in cars, or even pressed to plates for use in park benches for instance (cp. Baur 1996, p. 34).

- *Physical recycling* is a method to recover thermoplastic synthetic fibres like polyester, polyamide, polypropylene, or polyethylene (cp. Baur 1996,p. 35; Rouette 2006, p. 941). The material is shredded to flakes, and melted in order to be processed to fibres or other material subsequently. Depending on the purity of the material and its quality it can be reprocessed using recycling material only, or, if necessary, it can be mixed with virgin material (cp. Rouette 2006, p. 941). The loss of quality due to the thermal strain on the polymers could be reduced to a large extent enabling repeated recycling of the synthetic material (cp. Baur 1996, p. 35).
- *Chemical recycling* is still limited to synthetic fibres, however there are research and pilot projects on the chemical recycling of cellulosic fibres[48]. In chemical recycling the synthetics are depolymerised to monomers. Subsequently the feedstock is re-polymerized and can be processed to valuable fibres, e.g. for garment production, as the quality of the result is more predictable (cp. Fletcher 2008, p. 105). Purity of material is of importance here, too, although, in case of material mixtures, solvents can be used to precipitate one substance (cp. Baur 1996, p. 36). Commonly available chemically recycled fibres are synthetic polyester fibres made from PET plastic bottles (cp. Fletcher 2008, p. 105).

Theoretically, mechanical, physical and chemical re-cycling offer a great potential to recycle natural and synthetic fibres that cannot be reworn. Even chemical recycling, being the most resource intensive re-cycling process, is still considered more environmentally friendly than primary production (cp. Fletcher 2008, p. 103). Furthermore re-cycling delays incineration or landfill. The processes even allow using the material for high-value applications such as garments. However, in practice post-consumer textiles are mainly mechanically recycled to low-grade, non-woven applications like insulation material or hat rags for the auto industry. The reasons are mainly of technological and economical character: Fibre and raw material recycling technologies are not yet sufficiently developed or too expensive to process the majority of fabric (blends) in the market, as these are often not produced in a way that allows for high-value recycling within these processes (e.g. complex mix of fibres) and virgin material is comparatively cheaper (cp. ibid.). Hence, lack of high-value or closed-loop recycling is also an informational gap, as brands and designers do not consider recyclability in production and as recyclers do not exactly know about the composition of materials they process. As regards health aspects, due to being processed again, it might be that substances used in production accumulate in the product with each recycling process, which could cause a health risk to the later consumer ("danger-cycling") (cp. ibid., p. 105). Like the production of wipers, secondary raw material production does not cover costs in most cases (cp. Müller A.S. 2005, p. 102).

48 In Sweden there are two projects: Mistra Future Fashion (http://www.mistrafuturefashion.com), and Renewcell (http://renewcell.se), 09/09/2013.

4.3.2.3. Energy recovery and landfilling

Compared to any form of material recovery, energy recovery, and landfilling renders any further utilization of the resources impossible, which is why it should be put at the end of the recycling process (cp. Baur 1996, p. 37). Energy recovery often remains the only alternative for composite house textiles (e.g. upholstery), as material recycling would be too costly (cp. Baur 1996, p. 37). Textiles are generally considered nearly 100 % recyclable and usually the minority of textiles from the textile recycling stream has to be incinerated or burned (cp. Hawley 2009, p. 179). However, a large share of textile waste still ends up on landfill or incineration plants due to the inexistence of separate collection schemes or people not making use of them. Unseparated waste streams render recycling uneconomical and the material directly ends up either on landfills using land space and cause air and other emissions while rotting, or in few countries it is burned in incineration plants, which causes mainly air emissions (cp. Bilitewski & Härdtle 2013, p. 6; Rouette 2006, p. 939-940).

In textile recycling practice, about half of the material collected is reused as second hand textiles, most of which is exported to developing countries where it is sold on local markets. The remaining half is mainly downcycled to wipers and secondary raw material for industrial purposes. What cannot be utilised as raw material is either incinerated or dumped on landfills. Textiles are generally considered well recyclable and more than 90 % of textile waste can be processed by the textile recycling industry without producing any hazardous waste or harmful by-products (cp. Hawley 2011, p. 183). In that way, resources can be used more efficiently, and the production of products made from new materials can be reduced. However, the current large scale textile recycling system barely creates closed material loops in the sense of redirecting used (woven) textiles and garments back into the (woven) textile and garment industry. This is mainly because recycled fibres have to be deconstructed to fibre or even raw material level, which is a complex process that furthermore requires certain pre-conditions (such as purity of fibre or material colour) to be met, in order to make sure the result is of appropriate quality. For a number of reasons, this poses a challenge to the recycling industry leading to recycled fibres mostly not being competitive to cheap virgin fibres up to now.

Drawing on the weaknesses of industrial textile recycling today, the idea of upcycling as a concept of fashion design, specifically aims at diverting textile waste back into the textile complex. This technique of product or fabric re-cycling does not dissolve the fabric's structure in contrast to all other closed-loop re-cycling techniques. This reduces processing costs and saves resources. Most importantly, as upcycling works with given fabrics, it does not require purity of fibre or specific fibre compositions, nor does it require the exact knowledge about a fabric's composition. As a non-technical approach, fashion design upcycling can basically process any type of textile waste, even damaged and stained fabric. At the same time the number of processing steps in production can be reduced. This is shown in Figure 7, which depicts the different closed-loop recycling strategies for post-consumer textile waste.

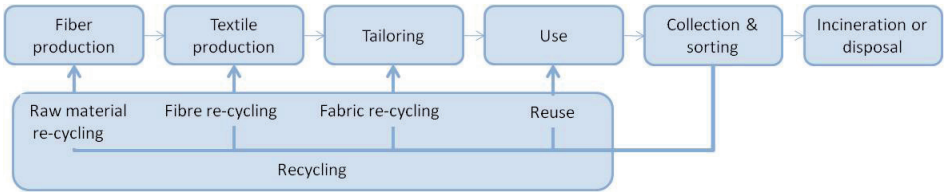


Fig. 7: Closed-loop textile recycling strategies

In contrast to fibre and raw material recycling techniques (mechanical, physical and chemical re-cycling), fabric re-cycling skips the processes of fibre and textile production, hence after being sorted and cut, the textile waste can directly be tailored (cut and sewn). Industrial scale upcycling could open up

a new sales market for textile recycling companies, to which these could sell especially non-rewearable fractions Due to being a high-value application, this might even help enable recycling companies to achieve prices that cover the costs of procurement and processing.

5. Textile Upcycling

Upcycling as a concept of fashion design emerged in the 1990s. In the last years, it experienced increasing popularity in the field of sustainable fashion (cp. Farrer 2011, p. 23-24). Still the market for upcycled garments is a niche market with diminishingly low volumes produced by small, independent labels. Although their products help create awareness of the issue of waste generation, this does not lead to significant environmental impacts and being premium price products, most of upcycled textiles is out of reach for the majority of consumers (cp. Aus 2011, p. 16). Moreover, the majority of upcycling companies focus on the processing of production waste or textile waste from institutional consumers. However, private households are by far the main producers of textile waste in industrialised countries, hence in order to enable the concept to lift its full sustainability potential, the utilisation of PCTW from textile recycling companies and a scale-up of production to an industrial level is needed.

This chapter presents the concept of fashion upcycling. As the concept is still rather young and barely described as such and as an approach to sustainable fashion, section 5.1. portrays the historical development and meaning of the term. Subsequently, section 5.2. tries to define upcycling the way it is understood today as a specific form of waste management– and describes different techniques of upcycling that could be identified in literature. A classification of different forms of upcycling based on the research of Aus (2011) is provided in 5.3. Furthermore, the section comprises a critical reflection of the conclusions she draws regarding scale of production and type of textile waste used by comparing her insights to current industrial upcycling practice and the types of textile waste used there. In section 5.4. the supply chain of industrial PCTW upcycling is modelled, based on the process model of Fraser (2009), the reverse supply chain as presented in subsection 2.2.3. and the supply chain of garment production as presented in section 3.2.Furthermore the major differences in comparison to the supply chain of virgin garment production will be described. Section 5.5deduces potential issues in industrially upcycling PCTW from textile recycling (sorting) companies based on the properties of the different types of textile waste and the supply chain model presented in section 5.4. Sections 5.4. and 5.5. function as the theoretical model that is reviewed and complemented within the empirical part of this thesis.

5.1. Upcycling in the context of sustainability

The term *recycling* does not make any value judgment. Recycling only describes the reuse of residues of production or consumption processes within processes of production or consumption (cp. section 3.1.1.). This might be due to the fact that in the beginning, around 1980, recycling was rather defined from a business perspective, as a result of the realization that the reuse of waste offers a potential for cost-savings. In the course of the 1980s and 1990s growing environmental awareness and constantly growing amounts of waste began to shape the understanding of recycling as an economical and environmental task (cp. Nickel 1996, p. 5). In Germany this led to the implementation of the so-called "Kreislaufwirtschafts- und Abfallgesetz (KrW-AbfG)"[49] (cp. Müller A. S. 2005, p. 73). The KrW-AbfG introduced the prototype of today's

49 The official term is „Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Beseitigung von Abfällen".

waste hierarchy: the priority order in § 5 distinguished between prevention, recycling, and disposal. At the same time, in order to be able to prioritize recycling options, an evaluation had to take place. With this the comparison of the initial product and the recycled product was introduced: in § 5 (2) 2 the avoidance of "downcycling" was formulated insofar as a high-value recycling appropriate to the kind and textile of the waste was demanded. In that way, implicitly, the idea of upcycling already found its way into waste management legislation. The term itself was factually created with reference to waste management only: it was first recorded in 1994 by Reiner Pilz who criticized the EU Demolition Waste Streams Directive and its recycling strategy: "Recycling, I call it downcycling. They smash bricks, they smash everything. What we need is upcycling, where old products are given more value not less" (cp. Pilz 1994 cited in Aus 2011, p. 43). In contrast to the KrW-AbfG which talks about high-value recycling (thus not excluding downcycling per se), Pilz defines upcycling as creating more valuable products through recycling.

In the following the idea of upcycling was "borrowed" by Michael Braungart and William McDonough who created the sustainability concept of "eco-effectiveness". This concept makes sustainability and with it upcycling a question of design. According to Braungart & McDonough (cp. 2002, p. 110) upcycling can only be achieved if the recyclability of a product has been incorporated in its design, otherwise recycling equals downcycling. Ever since its incorporation into the concept of eco-effectiveness, upcycling enjoys increasing popularity. The term *upcycling* as well as its assumed opposite *downcycling* are often used more or less randomly, even in scientific literature.

5.1.1. Upcycling as a principle in waste management

In its initial meaning upcycling was understood as an end-of-pipe, but creative solution to waste management. Pilz did not actually mean to design products differently in order to improve the way they could be recycled. He simply began using waste materials for his work as an interior decorator when the German waste disposal legislation had forced him to dispose of everything separately which increased costs by five times (cp. o.V. 1994, p. 13). Besides using waste as an input –however, he uses new materials as well– Pilz also tries to use everything from the resources he processes, but at the same time he considers health aspects, he wouldn't for example heat an oven with scrap wood before analyzing the paint used (cp. ibid.). In his work as a designer he reversed the regular process: he designs with what is available as it would not make sense to plan and then go looking for the appropriate waste (cp. ibid., p. 12). As regards recyclability itself, it is not mentioned that he considered it in his own designs. From a sustainability perspective Pilz follows the concept of eco-efficiency[50] trying to use material as best as he can. In waste management eco-efficiency is represented by the strategies of 3R: reduce, reuse, recycle (cp. Fletcher 2005, p. 99). Pilz does not aim at creating closed-loop systems or infinite material cycles. This idea of upcycling is mainly about the later use, i.e. the product that is made from the waste material. It does not explicitly define downcycling as decrease in material quality, although the Pilz' quote suggests that.[51]

50 The concept of eco-efficiency aims at reducing the resource flow of an economy. This can be achieved by an increase in resource productivity (quantitative) in terms of resource intensity, as well as increasing intensity and duration of use (cp. e.g. Weizsäcker, Lovins & Lovins 1995).

51 Definitions on downcycling are generally imprecise. According to Wollny and Peter (1994) downcycling means that the recycled material is used on a lower quality level compared to its prior purpose. The definition of Diekenheuer and Hasselmann (1994) is more precise: if material is not used for its primary, but a secondary purpose, one speaks of downcycling. Secondary use to them, however, implies that the utility value decreases with each process of

Redesigning materials requires physical rework like disassembling or cutting, which he also performs in his studio (cp. o.V. 1994, p. 12). The smashing of bricks to gravel, however, which is what the EU Demolition Waste Streams Directive contemplated as a later purpose for bricks, is what is considered downcycling in this context (cp. ibid., p. 10). Consequently, in this understanding of upcycling the prevention of decomposition of form is key[52] (cp. ibid.) as well as low-value secondary recycling.

5.1.2. Upcycling as an aim in the concept of eco-effectiveness

In contrast to its initial meaning, i.e. following Braungart & McDonough's concept, upcycling is rather understood as *upcyclability*. Hence, the founders of the cradle-to-cradle concept focus more on the initial product and the according product design than on the actual utilization of a product after it has become waste. This is not necessary insofar, as the later use of the material has already been considered while designing: In their opinion recycling follows the idea of closed (biological or technical) loops (cp. Braungart & McDonough 2002, p. 105-108). Therefore, recyclability in design plays a crucial role, for example as regards health aspects, and the threat of accumulating hazardous substances, as can happen in textile recycling[53]. As described above, in eco-effectiveness product follows design which in turn follows product. This clearly differs from the waste management approach.

Resource efficiency is not of major importance in eco-effectiveness. According to Braungart and McDonough eco-efficiency is not a design principle in nature, resources do not have to be saved as there is no waste and every material functions as a nutrient for following cycles ("waste equals food") (ibid., p. 92-96). As a result, the initial design of a product defines whether it will be recycled within a biological or technical cycle, and as regards technical cycles, materials will be re-used for the same purposes (closed-loop). This is one primary aspect in which the cradle-to-cradle concept differs from the concept of industrial ecology which focuses rather on open loops[54]. The upcycling concept of Pauli (1999) also belongs to this "school of thought". According to him upcycling is about connecting production processes through supply chains by transforming waste material from one process step to a higher product level (cp. Pauli 1998, p. 10). Upcycling is not just about improving the current recycling practice which he perceives as downcycling in most cases (ibid., p. 11). In both concepts –Pauli's and Braungart and McDonough's – downcycling is the logical consequence, if recycling has not been taken into account in product design, thus questions of direct or indirect recycling, primary or secondary utilization do not play an important role in their concepts.

The initial understanding of Pilz developed from the issues of waste management and the EU's plans to introduce a (cascading) recycling system that would establish systematic downcycling (cp. Kay & Matravers 1994, p. 10). It represents and end-of-pipe solution to waste management. This concept appreciates and emphasizes the value included in waste materials, hence focusing on creating something valuable again while using as much of the waste as possible. Recyclability does not seem to be a core aspect, whereas "zero waste" is part of the philosophy. In contrast, upcycling in eco-effectiveness is

recycling until it becomes technically difficult and economically unviable and hence has to be incinerated or disposed of (cp. Diekenheuer & Hasselmann 1994).

52 The partial of full decomposition of form has been described in section 3.1.1. as indirect recycling.

53 This has also been described in section 3.4.4. in the context of raw material re-cycling.

54 Industrial ecology takes natural ecosystems as model for human industrial activities. The interface between nature and economy, i.e. sources and sinks play a crucial role, and with it circular economy and recycling. Industrial ecology also focuses on product design and manufacturing processes (cp. Lifset & Graedel 2002, p. 3f.). However, in contrast to the cradle-to-cradle concept, industrial ecology rather focuses on industrial symbioses (cp. e.g. Gertler 1995), and eco-industrial parks and networks (cp. e.g. Lowe et al. 1996; Schwarz 1995).

based on thinking in material cycles from the very beginning. Thus the later utilization of products has to be planned in advance and has to be considered in the respective product design. Basically, the eco-effective concept of upcycling represents an advancement to the initial waste management approach. Where both approaches agree is that simple reuse does not represent a form of upcycling, as the products are not redesigned or remanufactured. Moreover, aspects of human health play a role in both understandings.

5.2. Upcycling in fashion design

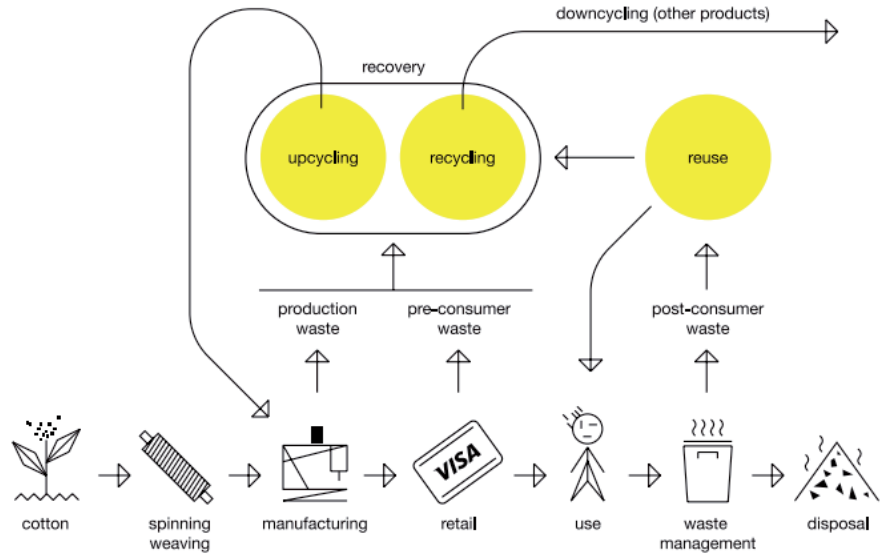
Upcycling, the way it is practiced today, uses waste materials that have been "manufactured in the cradle-to-grave paradigm" (cp. Dunn 2008, p. 5). It reflects an "end-of-pipe" solution to waste management with the aim to add value and increase resource efficiency. Farrer (cp. 2011, p. 35) describes upcycling as a process in which "broken, damaged, and redundant objects can be refashioned and value added through the process of upcycling". She, basically, describes it as an instrument of waste management for designers: "As a sustainable strategy for design, upcycling provides a designer with the opportunity to reassess the real worth and value of a waste material through the design and manufacture of new products. (...) This reuse and repurpose of existing materials allows a designer to divert textile matter away from incineration or landfill" (cp. ibid.). So does Aus (cp. 2011, p. 41): "The so-called upcycling method, or upward re-processing, is defined as bringing waste back into the consumption chain through design by placing it higher up in the chain than it previously was." The definitions of upcycling one can find in literature usually do not vary significantly. It seems to be agreed on, that upcycling "aims to guide textile waste back into production" (cp. Aus 2011, p. 41) in order to "give discarded, torn and stained fabrics added value, a new life and divert (or delay) waste from landfill" (cp. Fletcher 2008, p. 103). Aus (cp. 2011, p. 41ff.), however, clearly distinguishes upcycling from waste management methods, such as "Reduce, Reuse, Recycle", as it aims to add value to a product. In each of the definitions above, the value adding objective of upcycling is emphasized. In fact, it can be used as the criteria to distinguish upcycling from other forms of recycling. "Rather than recycling, which can result in downgrading of a material, informed designers are engaging in strategies such as upcycling to further prolong the life and value of a product and material (cp. Farrer 2011, p. 35).

Although often connected with eco-effectiveness, upcycling is not an eco-effective instrument, as it uses waste materials that have not been produced according to its principles. However, through emphasizing on adding value and the designer's role in this process, i.e. elements that are also part of the cradle-to-cradle concept and eco-effectiveness, the relation to and orientation at the latter becomes clear. Dunn (cp. 2008, p. 5) appositely describes the way upcycling is practiced today as a "step towards a cradle-to-cradle approach to design and an interim measure whilst more renewable, eco-effective materials are developed". Whether *upcyclability,* as a principle of eco-effective design, is also considered in current upcycling practice, i.e. whether upcycling companies aim to close their own supply chain through take-back and renewed upcycling, cannot be assessed. Aus (cp. 2011, p. 106), however, mentions that her designs consider the ability to reprocess the garment in fashion production.

In fact, upcycling is an instrument of waste management, more specifically, it can be regarded a specific form of recycling. When used in the context of textile recycling, in the waste hierarchy's priority order, upcycling usually ranges after second hand (re)use and before mechanical, physical and chemical forms of recycling. Fletcher (cp. 2008, p. 101) classifies upcycling a method of "repair and reconditioning", Hawley (cp. 2011, p. 150) describes it as "redesigning". It's design centricity and the principle of adding value, however, distinguish upcycling from traditional methods of managing textile waste. According to

De Castro (cp. Redress 2013, p. 6) "up-cycling needs to be differentiated from recycling or down-cycling, where textiles are recycled but often into a product of lower quality." Hence, upcycling follows a different approach to recycling. Up-cycling is all about "the recycling of a material into a product of *higher* quality" (cp. Redress 2013, p. 1). Hence, upcycling can take place on various levels: product, component or material level. Dunn (cp. 2008, p. 33) identified "four consistently recurring construction principles whose key words are reconstruction, embellishment, combination, and reconfiguration." Combination and embellishment can be considered forms of product upcycling, as the waste product is not deconstructed: In *Combination*, two or more waste products are joined together to form a new product. In *Embellishment*, the product is minimally altered, e.g. by applying additional decoration to the product's surface (cp. ibid., p. 97). *Reconfiguration* describes a rearrangement of components or elements of a type of garment into another particular form or another type of garment (cp. ibid., p. 98). Reconfiguration can be both, a type of product upcycling, in case the waste product is not disassembled, but it can also be a type of component or material upcycling in case the product's original structure is dissolved. Clearly, a form of component or material upcycling is *Reconstruction*, where textile waste is disassembled/deconstructed and altered, reworked or rebuilt (cp. ibid.). A technique commonly used in upcycling is *Patchworking* (cp. Fraser 2009, p. 16; Aus 2011, p. 13; Redress 2013 & 2013a). Patchworking can be regarded as the principle technique in upcycling and a mix between combination and reconfiguration. It is based on using different textiles or pieces of fabric and cutting and combining them to form a new product. When using production waste, i.e. scrap fabric, patchworking is the only upcycling method that can be applied.

As upcycling operates on various levels of recycling, it no longer follows the logic of the waste hierarchy. This distinguishes it from the 3R's approach to waste management, and makes upcycling an approach of its own that is based on the aim to add value through recycling. The relation between upcycling and recycling is depicted in figure 8. Upcycling is a generic term that comprises a number of tools or techniques that the designer can apply in order to add value to waste products.[55]



Source: Aus 2011, p. 42

Fig. 8: Textile recycling and upcycling

Another way to classify upcycling options apart from specific techniques is according to the type of textile waste used, i.e. whether production, pre-consumer or post-consumer waste is upcycled. In this context, reconstruction is described as "the process of making new clothes from previously worn garments or preformed products" (cp.

55 Apart from Dunn Fletcher (cp. 2008, p. 103) also names „a raft of techniques" in the context of upcycling „such as restyling, reshaping, embellishing, and overprinting". These are, however, not further explained.

Redress 2013, p. 9). The terms *Redesign*[56], *Refashion*[57], and *Restyling*[58] are also being used in the context of upcycling and especially post-consumer textile waste. However, there seems to be no specific term to describe the practice of using production waste as an input for textile production.

In the context of textile recycling, the term upcycling describes an alternative approach to waste management and an instrument of sustainable fashion design. Upcycling is a generic term that comprises a range of techniques to divert different types of textile waste from the waste stream and return them into the clothing or textile stream as high-quality products.[59]

Through its primarily design-led, value-oriented approach, former waste textiles can be moved "from the lowest to the highest level of the production cycle" (cp. Aus 2011, p. 42). This goes along with a revaluation of the designer's role in the process of fashion design, as the main input in upcycling comes from the designer (cp. ibid.). In its aim to prevent downcycling by means of design, upcycling follows a strategy, that has been incorporated by the sustainability principle of eco-effectiveness and the cradle-to-cradle concept. In its aim to increase resource-efficiency, prevent the generation of waste, slow down virgin textile production by diverting waste textiles from the waste stream and reproducing textile products, upcycling also comprises elements of the sustainability principle of eco-efficiency. Textile upcycling represents a sector-internal concept to "reduce the mountain of waste, whilst reducing the demand on raw materials required to manufacture new textiles" (cp. Fraser 2009, p. 16). Moreover, the potential of upcycling is seen in its handcrafted, non-industrial approach: "Compared to the (...) waste recovery strategies [Reduce, Reuse, Recycle], upcycling brings about the greatest change with the least amount of energy use" (cp. Aus 2011, p. 42). However, upcycling still embraces the idea of fashion, which is why Dunn (cp. 2008, p. 5) describes the concept as an "ideologically 'bright, green' approach, that accepts human need for renewal and meets this need in a way that stimulates thought about how we consume without sacrificing style or individuality." As upcycling is usually also linked to local sourcing and production, it is also regarded as an instrument "to resolving environmental and social issues related to the globalisation of the fashion textile industry and its reliance on transportation" (cp. Aus 2011, p. 43.).

5.3. Forms of textile upcycling

In the previous section, upcycling has been described as a primarily value-oriented approach to textile recycling and waste management. As a design-led method of sustainable fashion production, upcycling can take different forms. As it is a young concept, that the fashion industry only began actively talking about in the mid 2000s,up to now only a few generic forms of upcycling could be identified (cp. ibid., p. 43). One approach to distinguishing in upcycling is according to the type of waste material used (cp. Aus 2011, p. 48; Redress 2013a, p. 2). As shown in section 4.2., the classification refers to the life cycle phase, respectively supply chain phase, the material originates from. The classification according to waste is useful insofar, as the different types of textile waste have different features, that influence industrial upcyclability.[60] Another aspect for classification is whether unique or reproducible designs are

56 Hawley (cp. 2011, p. 150) describes redesigning as „restyling from used clothing".

57 Refashioning „intercepts discarded clothing, reclaims, re-cuts, and refashions, returning the item to the clothing stream, effectively creating a new loop and postponing its grave ending." (Dunn 2008, p. 5). Dunn (cp. ibid., p. 6) uses the term to describe „clothing made from PCR materials, including clothing, household textiles and other materials not originally intended for use in clothing."

58 cp. Hawley (cp. 2011, p. 150), Sherburne (cp. 2009, p. 8).

59 De Castro (cp. Redress 2013, p. 8) describes upcycling as „an innovative method of recycling textile waste into products of higher quality, for example by up-cycling textile swatches, production off-cuts and end-of-roll textiles to create higher quality garments.

60 See section 2.2.1. and section 5.4.4. subsequently.

produced (cp. Redress 2013a, p. 2f.). Aus (cp. 2011, p. 121) differentiates three forms of upcycling based on the scale of production and whether it is done professionally:

- Private persons that individually sew at home as a Do-It-Yourself (DIY) concept
- Independent designers/ small producers working in a studio producing one-offs
- Small scale or mass producers that use upcycling in serial design

If consumers upcycle themselves they rather use their own used clothing, i.e. post-consumer textile waste. This diminishes their need to buy new products, prevents waste generation and allows textiles to be produced with the least amount of resource input (cp. ibid., p. 125). In DIY, there is no need for transportation as the consumer acts as producer ("User as Maker" (cp. Fraser 2009, p. 16), directly closing the loop. Hence, there is no need for transportation. On the other hand, the consumer has to have certain skills in sewing and a willingness to invest time and resources in upcycling his or her own textile waste.

In fashion design business, independent designers and small labels use upcycling in order to produce one-of-a-kind products. Usually, due to its unique character and it's patina, post-consumer textile waste is a popular raw material for the production of one-offs (cp. Dunn 2008, p. 40; Fletcher 2008, p. 103; Hawley 2011, p. 150). However, at that stage designers frequently use a mix of the various types of textile waste (cp. Aus 2011, p. 121). While each item is original, the production of one-offs is very labour-intensive and time-consuming, which results in higher prices (cp. Aus 2011, p. 122; Hawley 2011, p. 150).

In order to decrease production costs through *economies of scale*, and to achieve a greater environmental impact, upcycling companies can apply serial production. This can comprise the "multiple production of one-offs", which describes a small scale production of standardized design models (cp. Dunn 2008, p. 6), as well as the production of larger series up to mass production of standardised designs. According to Aus (cp. 2011, p. 50) using production waste is easiest for serial and mass production, due to the availability of large quantities and regular material flows and due to the high quality of the material. Consequently, at the stage of mass production, she only distinguishes two strategies of upcycling: A company uses its own production waste for upcycling or production waste is obtained from other textile producing companies (cp. ibid., p. 123). As in the latter case, costs of transporting, sorting, classification, and washing incur, she considers the former strategy more prospective (cp. ibid., p. 124).

When describing the three forms of upcycling, Aus links each one to certain types of textile waste, postulating, that for the various forms and the respective scales, some types of textile waste are more appropriate than others. From her own research and practice, she finds that for serial and mass production, production waste is easiest to upcycle, because the produced volumes are generally quite large and regular (cp. Aus 2011, p. 50). However, Aus' insights are based on research that has been performed in an Estonian context, where the availability of pre-consumer and post-consumer textile waste is limited. As regards pre-consumer waste, i.e. mainly sales-leftovers, the Estonian market is small and so are the quantities of garments offered (cp. Aus 2011, p. 49). Concerning post-consumer waste, Estonia still lacks a large-scale textile recycling system, that could provide bigger amounts of post-consumer waste to upcycling companies (cp. ibid., p. 48).

When looking at other practical examples, up to now most of the businesses that apply upcycling to garment and other textiles production operate on a very low scale, usually producing one-offs. As regards serial production, the principle has rather been applied by fashion companies, that operate on a small to medium scale. (cp. ibid., p. 121, 123). Many of these are situated in Europe

and particularly the UK. *From Somewhere* is a British upcycling company, which exclusively uses pre-consumer surplus from the luxury fashion industry (cp. From Somewhere 2013). However, in 2010 *From Somewhere* designed a collection for Tesco using their own production waste and one year later, in 2011, the company worked with Speedo to upcycle their unsold swimming suits and other pre-consumer waste (cp. de Castro (2010) cited in Aus (cp. 2011, p. 44), Upcycling Fashion (2011)). *Goodone* is another British upcycling brand, that produces series available at a number of stockists worldwide (cp. Goodone 2013). The company combines post-consumer textiles that it sources from recycling companies with organic virgin materials in order to standardise the designs and make them reproducible (cp. Redress 2013, p. 2). To minimise production costs *Goodone* has established a manufacturing site in Bulgaria in order to "offer affordable, mass-produced garments" (cp. Goodone 2013). The Finnish upcycling brand *Globe Hope* produces quite a large range of products (garments, bags, shoes and accessories) using a wide range of materials, many of which are pre-consumer (dead stock) and post-consumer waste from institutional consumers. *Globe Hope* processes discarded military textiles, work wear and uniforms, and used advertisement banners made from tarpaulin. Moreover, the brand processes post-consumer waste from private households that it sources from textile recycling companies. (cp. Globe Hope 2013). The business model of the British label *Worn Again* is based on upcycling work wear and uniforms. *Worn Again* co-operates with companies that produce larger amounts of textile waste and upcycles their material to new products they could use again within their organisation (cp. Worn Again 2013). Reet Aus (Aus Design Ltd.) seems to be the only designer that upcycles textile waste in an industrial way by exclusively using production waste. Her Spring/Summer collection 2013 has been produced at Beximco Ltd, a vertical fabric and garment manufacturer company in Bangladesh using their fabric waste which could be directly reprocessed at the same production site (cp. Trash to Trend 2013).

To what extent the previously mentioned companies produce on an industrial scale is not clear. However, the examples show that many upcycling companies involved in serial production do not limit their input materials to production waste. On the contrary, it rather seems that most of them use post-consumer waste which, however, originates from a range of different sources. The reason might be that both pre-consumer and post-consumer wastes offer a wider range of upcycling techniques to be applied to these already finished products, whereas production waste can only be upcycled, using the patchwork technique.[61] This comparison to upcycling practice backs the finding of Dunn (2008) and Fraser (2009) that post-consumer textile waste offers the potential to be upcycled in an industrial production model.

5.4. A supply chain model for industrial upcycling of PCTW

Fraser (2009) developed a model of a standardized textile upcycling process, which is based on the process of industrial textile production. In this chapter, this model is presented and, with reference to the recycling chain (section 2.2.), slightly amended which provides a higher degree of generalisation. Extended by economic aspects, taken from the supply chain of a textile or fashion brand (section 3.2.), this forms the supply chain of industrial textile upcycling of post-consumer waste. Although based on a process model for upcycling PCTW, the upcycling model is still generic enough to cover all kinds of textile waste. This is because the diversity of the input material makes it hard to draw a clear differentiation between the various types of textile waste. So at that point, the waste materials, that upcycling companies work with, will be regarded as simple raw materials that a fashion brand uses. Thus, this section will not look at the entire textile complex, but only at what has formerly been described

61 The various techniques have been described in section 5.2.

as the supply chain of garment production. The transformation processes (material flow) and the transaction processes, i.e. mainly the actors involved, will be regarded separately.

5.4.1. The industrial manufacturing process of PCTW upcycling and differences to virgin production

The standardised upcycling process model of Fraser (2009) is depicted in figure 9. The graph also shows the consumption process of buying and using male trousers, as Fraser's approach to standardising the upcycling process of PCTW is based on the selection of a commonly available type of garment that is semi-standardised in size and shape and also of good quality (cp. Fraser 2009, p. 31).[62] Those three criteria are important factors in upcycling: There seems to be general consensus that the (high) quality of the raw material is a prerequisite for a materials suitability of use in upcycling (cp. Aus 2011, p. 50; Fraser 2009, p. 38, 55; Redress 2013, p. 3).[63] As will become clear in the following, bulk availability and standardisation of raw material only enable to make use of cost advantages that industrial production provides (rationalisation and economies of scale).

Based on Fraser's model, the manufacturing process can be divided into five major steps (cp. ibid., p. 44-50):

1. Physical sourcing: The sourcing and selection of feedstock (including grading by usability and quality)
2. Preparation for processing: Recording garment details, Professional cleaning[64]
3. Disassembly: Unpicking of seams, Pressing
4. Cutting: Pattern placement, Marking and Cutting
5. Reassembly: Bundling with trims in multiple groups, Garment sewing, Pressing

Source: Fraser 2009, p. 50

Fig. 9: Standardised upcycling process model

62 Aus (cp. 2011, p. 70-71) created a collection in a similar way: She used worn jeans, washed them, cut them to pieces and sewed them together. In the end she concluded: „The use of post-consumer waste in this way creates the scope of upcycling similar materials on a large scale" (cp. Aus 2011, p. 71).

63 However, Aus (cp. 2011, p. 146) eventually concludes that upcycling offers the potential to use textile waste „despite the (...) quality of the textile material."

64 Dunn (cp. 2008, p. 40) describes the entrance procedure prior to washing as follows: "Newly sourced materials are sorted into piles such as compatible to wash together, discard, clean in another way than with water, doesn't need cleaning, etc. The amount of cleaning or mending required is assessed in terms of what is acceptable patina and whether the nature of soiling is such it can be remedied."

Compared to the reverse supply chain developed in section 2.2.3., the process model of Fraser basically only varies in one minor aspect.[65] The recording of the raw materials' details is not mentioned in the reverse supply chain, the reason for this might be that in this model the task is part of the upstream process of checking, grading and sorting. In the following it will be considered part of that process.

When developing the upcycling process model, Fraser orientates herself towards the process of industrial textile production that operates on the principle of *Economies of Scale* which allows an increasing reduction of per-unit costs (fixed and variable costs) the more products produced (cp. ibid., p. 36). This proceeding eventually allows her to compare both processes and to realise that the processes differ in some aspects, marked numbers 1 to 4 in figure 9 (cp. ibid., p. 49):

1. Where in regular (virgin) garment manufacture, rolls of fabric are used, the upcycling process uses individual raw materials (trousers).
2. This raw material has to be prepared in advance, which requires additional steps of processing: Recording, Cleaning, Unpicking, Pressing.
3. Pattern placement in virgin textile production is standardised due to using standardised fabric roles. In upcycling pattern placement is complex due to the diversity of the raw materials' measures (e.g. length and width).[66]
4. In virgin textile production multiple layers of fabric can be cut at a time due to the standardised materials input (cp. ibid., p. 37), in upcycling the fabric has to be cut individually (single layer cut), and the cutter should be an expert (cp. ibid., p. 48).

These differences primarily arise from waste being non-standardised material and all result in upcycling being a very labour-intense and more expensive process than virgin textile production. Due to the individual raw material, the upcycling process requires a number of extra steps (checking/grading/sorting/recording, cleaning, unpicking and pressing) and cannot be rationalised to the same extent (non-standardised pattern placement, single-layer, expert cut). Apart from these differences, however, the manufacturing process of upcycling equals virgin textile production (cp. Fraser 2009, p. 49).

5.4.2. The supply chain of industrial upcycling

Apart from the physical sourcing and production process, the supply chain of garment production and hence the supply chain of an upcycling company comprises a range of further tasks. The upcycling manual provided by Redress (2013a: 2-5) summarises these in four major steps: Deciding whether to produce unique or reproducible products, sourcing textile waste, designing the product, producing the product. The question, whether to produce unique or reproducible products, is dispensable in this case, as industrial upcycling implies the manufacturing of reproducible products.

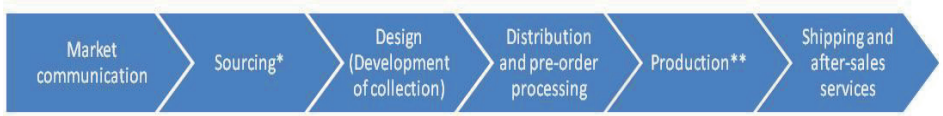
In contrast to Fraser's description, this proceeding starts off with the sourcing of materials which is only then followed by the design of the model. In fact, the dependency of design on the input material available is one of the key characteristics in upcycling: When upcycling post-consumer textiles the "design process starts with a finished garment, meaning that there is little or no

65 The reverse supply chain also considers distribution; this is, however, not part of Fraser's manufacturing process model. As the latter applies to garment production specifically, it is hence more detailed. In general, the processes correspond.

66 Dunn (2008, p. 6) describes the complexity of upcycling that still remains although one specific type of garment has been identified as follows: "As an example, the only common factor ten skirts have is that they are all tartan, being otherwise all different styles, colours and fabric types. There is no standardization of sizing, construction or quality in garments sourced."

separation between the conceptualisation and realisation aspects of the design process" (cp. Dunn 2008, p. 39). Aus (cp. 2011, p. 47), too, emphasises that "it is important to have an overview of the textile waste available, because this is what dictates the garment that can be created". In the following Aus concludes that the first step should be "to carry out a local textile waste study" (cp. ibid.). This is basically what Fraser did before identifying male's trousers as a suitable type of garment for industrial PCTW upcycling and designing a dress from it. As a result, the actual design process and the materials' sourcing and production process have been separated like in regular textile production based on meter fabric (cp. section 3.2.). While this strategy only enables the serial upcycling of post-consumer textiles, the designer is still not free to choose whatever fabric material he would like, as he depends on the textile waste available. So in general terms, in upcycling design follows sourcing. As a consequence, and in contrast to virgin production, in the supply chain of textile upcycling, sourcing precedes design and with it (economic) distribution.

Considering the supply chain of garment manufacture (section 3.2.), the reverse supply chain (section 2.2.3.) and Fraser's manufacturing process, the following model of the supply chain of industrial upcycling is developed:



* Sourcing includes checking, grading, sorting and storage of material
** Production includes cleaning, disassembly, pressing, reassembly and pressing

Fig. 10: The supply chain of industrial textile upcycling

Apart from additional steps that the sourcing and production processes requires, when industrially upcycling textile waste, the major difference between the supply chain of upcycling and the supply chain of regular textile production seems to be the enhanced relevance of the sourcing process, which all the following supply chain steps depend on, especially design. This is not surprising when considering the fact that the production process and the amounts that can be produced from a certain input material are based on the raw material available: If upcycling is to be performed on an industrial scale, in order to be able to realise economies of scale, the input has to be as standardised as possible and available in bulk (cp. Fraser 2009, p. 38). A steady supply, if possible in predictable amounts, further facilitates production and sales planning (cp. Aus 2011, p. 50).

Depending on the specific raw material and its source, some steps (e.g. cleaning) might be skipped in order to increase the economics of the process. Production scraps in general do not require unpicking. The characteristics of the waste material play a vital role here. This again emphasises the relevance of sourcing, which (apart from collection development and distribution)[67] can be assigned a key success factor in upcycling, as not only the suitability, but also the price can make a huge difference in terms of economics of upcycling: When interviewed by Aus (cp. 2011, p. 183), Orsola de Castro, designer at the upcycling label *From Somewhere*, points out: "From Somewhere dresses in Tesco are cheaper than anything else since waste costs one third of the normal material."

Besides variations in the value chain, upcycling can also involve the participation of actor that are usually not involved in textile production different actors compared to usual textile production. The influence of post-consumer textile waste on the crucial phases of upcycling and potential issues will be discussed in section 5.5.

67 See section 3.3.

5.4.3. *Actors and transaction processes*

The main actor in upcycling is the upcycling brand itself. It can be regarded as the focal company in the upcycling supply chain, as it organises all necessary processes. The second most important group of actors in a demand-driven market is represented by the customers, i.e. retailers, and end-consumers. In case the industrial upcycling brand has outsourced physical production to a manufacturing company as service provider (e.g. in order to decrease costs), these service providers represent a third group of actors. However, as sourcing has been identified a key success factor in upcycling, this third group is not as important as the suppliers who provide the upcycling brand with appropriate raw materials. Compared to virgin textile production, the groups of actors and the roles they play are identical in textile upcycling, as the use of secondary instead of primary material basically makes the only difference between virgin production and upcycling. Hence, the types of transaction processes an upcycler is involved in, are also similar to primary production.

Nevertheless, especially with regard to sourcing, there are some characteristics in upcycling that concern the type of actor as supplier and that influence transaction processes: The virgin garment industry sources its raw materials (fabrics, trimmings, etc.) from the wider textile industry as has been described in section 3.2. In doing so, the industry is restricted to only one type of supplier (providers). In textile upcycling the picture is different. As upcycling represents a form of waste management, upcyclers are, basically, a specific form of waste management enterprise, which provides a recycling option for different types of textile waste generated along the supply chain of a textile (see section 4.3). Hence, its raw materials (mainly garments or fabric) can be provided by all actors upstream, that generate textile waste. This comprises (cp. section 2.2.1. or Dyckhoff & Souren 2007, p. 58; Dyckhoff et al. 2004, p. 18 and section 4.3.):

- *Providers*, i.e. producers that generate production waste such as end-of-rolls or cutting scrap as well as producers and/or retailers that produce sales-leftovers
- *Consumers*, households as well as public and private enterprises that produce post-consumer waste
- *Disposers*, public or private enterprises such as second hand shops and textile recycling companies that process post-consumer textile waste[68]

Linking those potential suppliers to the different types of textile waste as described in section 4.2, the following relations can be identified:

	Providers (fashion brand/ manufacturer, retail)	Consumers (private households/ institutional consumers)	Disposers (charities/ textile recycling companies)
Production waste	✚	▬	?
Pre-consumer waste	✚	▬	?
post-consumer waste	?	✚	✚

Fig. 11: Types of textile waste according to type of supplying actor

As regards providers, fashion brands and manufacturers are able to provide upcyclers with production waste. In case fashion brands distribute via own shops, have dead stock or take back their pre-consumer waste, they might also be able to supply this type of waste. Retailers can provide pre-consumer waste (sales leftovers). Fashion brands and retailers might also be able to supply post-consumer waste, as within recent years a number of brands have started to use take-back systems.[69] Private and institutional consumers provide

68 Textile recycling companies might also process production and pre-consumer waste.
69 See section 4.3.1.

post-consumer textile waste only, although it might be possible that some of the material has never been used. Such material could rather be considered pre-consumer waste. Disposal or recycling companies, such as charities and textile sorting companies, also provide post-consumer textile waste only. Depending on their supply chain however, especially textile recycling companies might also process production and pre-consumer waste.

Another specialty regarding actors and transaction processes within the upcycling industry is that the potential suppliers of any kind of textile waste, that is producers (providers and consumers) and waste processors (disposers), usually, have a range of options to discard or use their material. There are a number of markets for waste: the raw materials market, consumer or business-to-business markets, as well as the market offering waste disposal services (cp. Gelbmann 2010, p. 100). In the case of textile waste, disposal options comprise: unseparated collection (residual waste), separate collection (textile recycling industry), producer or retail initiated take-back systems, selling to consumers (e.g. ebay) or businesses (e.g. to textile industry, merchants, second hand shops) (cp. section 4.4.). So in their demand for raw materials, upcycling companies compete with a range of other options, meaning that suppliers will face opportunity costs when deciding for one or another option. Moreover, the process for choosing any of the options available, is connected to information and coordination costs (transaction costs). Both opportunity and transaction costs, can influence the potential supplier's motivation to cooperate with an upcycling company. Hence, the price that upcycling companies are willing to pay for their raw materials (and the costs respectively the market price of the other options) must be a decisive factor.

5.4.4. Factors influencing the industrial upcyclability of textile waste

Within the previous sections, four factors that determine industrial upcyclability could be identified. In order to mass produce products and profit from the opportunity of process rationalisations and economies of scale, input materials have to be standardised and available in large quantities (section 5.4.1. and 5.4.2.).[70] Upcycling companies also seem to consider a raw materials' quality an important factor for upcycling in general (section 5.4.1.). The value or price of a material is another important factor as it affects both, the willingness of the sorting company to sell the material to an upcycling company (see section 5.4.3.) as well as the economies of the process of the upcycling company (see section 5.4.2.).

However, standardisation, quantity, quality and price are interrelated to some extent and each of the factors is influenced by the degree of deterioration[71]: It affects the standardisation of textile waste as deterioration characteristics vary according to material characteristics and pattern of use (see section 2.2.2.). Deterioration also affects the quantities that can be sourced as with a certain degree of wear (even economical) materials cannot be processed in certain recycling processes (see section 2.2.2.). Quality in general suffers from deterioration (e.g. stains, holes). Deterioration also affects the embedded value and therefore the price of a material. Generally speaking: For a recycling company, the lesser the need for processing, the lower the costs and the higher the price that can be achieved, hence profit can be maximised (see section

70 "The allocation of upstream products in the right quantities and qualities at the right time" is an important success factor in textile production (cp. Appelhans 2002: 25). As regards time, Aus (2011: 124) also mentions the regularity and predictability of supply as factors that facilitate production and planning (see section 5.4.2.). However, the factor of time will not be considered separately as it is covered by the factors "availability of quantity" and "quality".

71 As deterioration affects all other influencing factors, in the following it will not be considered separately, because it is already indirectly covered.

4.3.2.). Furthermore, for an upcycling company, deterioration influences the complexity of processing (checking, cleaning, cutting), and hence affects the economies of the process.

5.5. Potential issues in crucial phases of industrial upcycling of PCTW

When modelling the supply chain of industrial upcycling in the previous section, it became clear that sourcing and supply[72]are key success factors. It is the supply chain phase that all subsequent stages rely on. In general in the fashion industry, design (collection development) and distribution are considered crucial success factors in the supply chain (cp. section 3.3.). Hence, in (industrial) upcycling there are three crucial phases: Sourcing, design and distribution.[73] Potential issues in upcycling PCTW from industrial textile recycling companies are described in the following. Due to the complexity of the matter, only the crucial phases will (can) be regarded and potential challenges are described on the basis of the four factors standardisation, quantity, quality and price.[74]

5.5.1. Sourcing

Industrial production is based on standardised large-scale production that requires bulks of equal raw materials in regular intervals in order to realise process rationalisations and economies of scale. Section 4.2. described general differences in the various types of textile waste and in section 5.4.3. these were linked to certain types of suppliers. Sourced from the various suppliers, the textile waste differs with regard to its degree of complexity (fabric or finished product), degree of standardisation (which includes degree of deterioration (cleanliness, holes, stains and other flaws) and in terms of regularity and amounts of waste that can be supplied. As Fraser's comparison between virgin textile production and upcycling has shown, the latter's production process is more complex and can never be as cost efficient as virgin production, due to the **non-standardisation** of the input material:

Upcycling companies have to find raw materials and suppliers that allow 'best' for industrial production. Post-consumer textiles from private households are the least standardised raw materials, as they usually consist of one-of-a-kind items that differ in type (t-shirt, jacket, pants), materials composition (cotton, wool, mixtures), colours and degree of deterioration. Due to their context of origin, they have a high degree of deterioration compared to the other types of textile waste. Low degree of standardisation and high degree of deterioration both lead to post-consumer textiles having to be sorted properly according to a number of factors and on top of that, they will usually have to be cleaned which increases the costs of processing (cp. Aus 2011, p. 52). Post-consumer waste from institutional consumers provides the advantage, that the materials usually do not or far less vary with regard to fibre material, shapes and colours. Uniforms or work wear usually only differ in size and due to different use pattern also in deterioration. Post-consumer waste, due to being composed of finished products, additionally, has to be unpicked before patterns can be placed and

72 The term procurement management would be more appropriate in this case: It describes the strategic tasks of procurement market research, request and tenders, negotiation, assessment of tenders, contract formation, and performance measurement (cp. Werner 2013, p. 16).

73 Due to upcycling resulting in a more costly production process, production phase is also important. This phase, however, depends largely on sourcing, hence process optimisations in this phase will mainly result from sourcing and as regards the upcycling technique allied also on design.

74 Production or processing is also an important phase. As it is largely dependent on sourcing and design, it will be covered within these two phases. To a large extent, potential issues in production were already dealt with when modelling the supply chain and identifying the differences to regular textile production.

cut. "Unpicking is labour intensive so the more unpicking that occurs, the more expensive the garment will be" (Dunn 2008: 46). This processing step can be skipped entirely when using production (fabric) waste. Whether and to what degree unpicking is necessary also depends on the complexity of the material (number of components) and the upcycling technique used(cp. Dunn 2008, p. 46).

When using post-consumer waste as a resource, industrial upcycling companies will be restricted to choose common products (like Fraser did) in order to provide larger **quantities** of rather standardised products. Demanding vintage products or items made from uncommon materials like e.g. pure silk will not be suitable to provide large quantities in regular flows.

A general requirement in upcycling is the **quality** of the raw material, which is supposed to be high (see section 5.4.3.). It is not clear what "quality" refers to, i.e. whether it refers to intrinsic characteristics such as quality of material and processing or also to the degree of deterioration.[75] The quality levels of the items sourced from textile recycling companies will vary due to the lack of standardisation. On top of that, due to fast fashion gaining more and more ground (section 3.3. and section 4.3.), the average quality of the items that textile companies process has decreased (sections 3.3. and 4.3.). According to Aus (cp. 2011, p. 50) "the quality of fabric and sewing is also often so poor that reusing used garmentsispracticallyimpossible.Forthesamereason,alargeamountofthismaterialisalsounsuitableforredesignand upcycling". Average insufficient quality might be another limiting factor for upcycling companies to not use post-consumer waste from textile recycling companies.

Apart from the upcycling company's motivation to source a specific type of textile waste from a specific type of supplier, in this case textile recycling firms, the **motivation of the suppliers** to co-operate with upcycling companies might also vary. As a pre-requisite, there needs to be a surrounding infrastructure that can provide the company with the required amounts of input materials, i.e. a large-scale textile recycling system for processing private consumers textile waste has to be given. Although this generic condition has to be fulfilled in every kind of production, local availability in upcycling can be of particular importance, if using local waste is part of the philosophy (like in the cases of Aus and Fraser).[76]

As described in the previous section, suppliers have transaction and opportunity costs when deciding to co-operate with an upcycler, as those actors have at least one other option to dispose of their waste (unseparated residual waste stream) and usually will already have decided on a disposal solution in the past. On the positive side, disposal into the unseparated waste stream is linked to the payment of waste collection fees. Hence, it can be assumed that other options are generally preferred from a financial perspective. However, textile upcycling companies differ in that regard as dealing with textile waste is core of their business. As described in section 4.3.2., they have a broad range of options on how to make use of discarded textiles because they already have a sorting and distribution system in place. In general, the co-operation between both types of business has to be based on the compatibility of the recycler's sorting process with the criteria that upcycling companies set on the textiles they source. A co-operation might require adaptations in the sorting process on their behalf, and there will be no motivation to give suitable textile waste to upcycling companies for free or very low prices due to the existence of opportunity costs. So the price, that an upcycler is willing or able to pay for its raw materials, will be decisive in this context. This might be different for production and pre-consumer waste where both types of suppliers usually cannot make

75 Aus (cp. 2011, p. 79) considers certain types of fibres namely polyester a low quality material: "The garments were made out of polyester fabric. Since this is not a high quality material, it would have been difficult to upcycle it into a high-quality design product."

76 Compare also Gelbmann 2010, p. 98.

use of their waste that easily. Considering the inferior quality/suitability of the material this conflict of interest might be decisive. However, as textile recycling companies by law have to follow the waste hierarchy which aims at high-quality recycling, there should be an environmental motivation to co-operate with upcyclers.

As a result of low standardisation, deterioration and decreasing average quality, recycling companies might not be able to provide suitable material in sufficiently high quantities to textile upcyclers. Furthermore, low standardisation, deterioration and product complexity make upcycling of PCTW more costly compared to other types of textile waste. In the light of the lack of a supplying infrastructure and a lack of motivation on behalf of recycling companies respectively, high prices for the raw materials, upcycling companies might prefer to use other types of textile waste and co-operate with other types of suppliers.

5.5.2. Design

The design phase is the second crucial phase in the supply chain of an upcycling company. Using textile waste as an input material is "not the easy way to design" (cp. Hawley 2011, p. 150). Upcycling is generally more challenging than working with virgin material as the designs are largely dependent on the material available (cp. Farrer 2011, p. 35; Aus 2011, p. 141). Especially in industrial upcycling, designers are required to use common products in order to secure sufficient **quantities** of supply. "For instance a designer needs to be mindful of the condition of the raw materials noting stains, holes or areas of fraying, while also working out a method for the careful deconstruction of an existing garment" (cp. Farrer 2011, p. 35). Thus, there might be a general lack of motivation on behalf of designers and fashion brands to work with waste as a resource. This might especially count for serially upcycling post-consumer waste from recyclers, as the high degree of **non-standardisation** makes developing repetitive designs from post-consumer textile waste even more complex and limits the designer's freedom to use certain materials, colours, patterns or even shapes.

Designers/brands might also think that such restrictions limit the opportunity to follow specific fashion trends as certain types of materials or colours might not be available, and additional dyeing e.g. would represent another process step causing costs while also involving uncertainty concerning the result. With the garment industry being a highly competitive, **price**-driven industry that orientates itself at fast changing fashion trends (section 3.3.), most garment producers will not consider upcycling a viable business (model). As the upcycling process for post-consumer waste is the most complex and therefore the most expensive compared to other waste materials, a designer or fashion brand has to have more than merely an economic **motivation** to engage in this field. "Upcycled labels are usually independent brands. The choice of material and method is not motivated primarily by beneficial opportunity or current trends, but from concern for sustainability" (Aus 2011, p. 43). An independent label usually won't have the financial clout and the respective manufacturing network and sales market to mass produce, which could be a hindrance to mass production in upcycling.

Another aspect, that also refers to the designer or the brand's **motivation** to engage in serial post-consumer upcycling, is that using post-consumer textile waste in upcycling is "often incorrectly considered to be an exclusive design approach, since the designs are often not easily reproducible, owing to the variable supply of working materials" (Redress 2013a, p. 2).Whether they are, depends significantly on the designer's/brand's aspiration: "However, this depends on what type of reconstructed garments you wish to create; for example exclusive reconstructed couture or a more casual reconstructed T-shirt". The **upcycling technique** applied (that goes with the degree of deconstruction of product) plays an important role here. Although it largely influ-

ences the processing steps required, from a designer's perspective, embellishing garments must be less interesting than creating new ones through reconstruction.

Being restrictive in raw material choice and more challenging to design, designers/brands, and especially conventional and big players, might not be interested in (PCTW) upcycling. The complexity and restrictions might also pose a risk too high to take in a highly competitive market such as fashion. Upcycling (PCTW) being generally more complex and harder to standardise and thus more costly, other motivational factors such as a serious environmental concern will play a role, especially as there are other, easier ways to produce sustainably by e.g. using organic fabrics. Lack of industrial upcyclers using PCTW from recycling companies can also be based on upcycling being a design-centric concept. Designers might prefer to create one-off pieces instead of casual pieces and if involved in upcycling it might not be satisfactory to "just" embellish a garment instead of reworking it entirely.

5.5.3. Distribution

According to Dunn (cp. 2008, p. 22) the acceptance of used materials by the market is crucial for the acceptance of any refashioned product. In upcycling and especially post-consumer upcycling induction gaps might occur insofar, as processing is too expensive, respectively **price** differences between recycled and virgin products are too low compared to **quality** deviations (see section 2.2.2.). If the upcycling process is more costly, raw materials have to be significantly cheaper, otherwise upcycled products will be more expensive. Due to high cost, respectively price pressure within the industry and the general popularity and abundance of cheap, fashionable (fast fashion) products, upcycled garments face fierce competition. Even on the sustainable fashion market, upcycled products will be more costly than other products made from recycled or organic meter fabrics. Furthermore, upcycled products might show wear marks when made from post-consumer textiles, which could affect consumers' willingness to pay: Aus (cp. 2011, p. 13) explains that although the media and the people admired her work, "retailers would not buy it because the high volume of work involved made the price of each piece too high and they thought that the consumer would not be ready to pay so much for clothing made from reused materials". There might be a prevailing **expectation** on behalf of retail and customers that garments made from used clothing have to be of equal price or even less expensive than virgin ones (cp. Aus 2011, p. 142). With a higher or relatively high price, expectations on **quality** of the product could also be high. This would result in both an increase in processing costs (which again affects price) and the necessity to use only high-quality raw materials that are hard to source if the majority of textiles recycling companies only provide low-quality.[77]

Apart from prices, the textile's history, it's *patina*, is an important element in upcycling (cp. Dunn 2008, p. 40). However, the **motivation** to buy upcycled products might lack, as deterioration characteristics such as wear marks –little holes or stains and the simple fact that the textile has been worn by a stranger before– are very individual factors that might keep the majority of people from buying upcycled products (just like the majority of people does not buy second hand products). This might also be linked to what Fraser (cp. 2009, p. 17) calls an "obvious remake aesthetic" of upcycled garments, which makes them exclusive products suitable only for a limited target group that might on top of that be motivated to buy upcycled products for sustainability reasons. Hence,

77 Aus (cp. 2011, p. 58) concludes that a lot of used garments cannot be reused other than for theatre costume design:"This is because theatre costumes do not set such high demands in terms of the quality of the raw material as retail clothes tend to. Thus, this experience also confirmed that a large part of post-consumer textile waste must be recycled outside the clothing industry because the quality of the material is so low that it cannot be sent back into the consumption cycle."

only being suitable to a small target group might affect **quantities** that can be sold. Lack of **standardisation** (e.g. colours, fabric quality) might also be an issue in distribution.

The lack of industrial upcycling of PCTW can be based on induction gaps; like insufficiently low price differences between upcycled and virgin raw materials, insufficient material quality and additional processing costs that result in prices of upcycled products being too high compared to consumer's expectations regarding price, quality, and standardisation, or their general motivation to buy upcycled textiles. The particularity of upcycling might also result in a lack of market size.

Figure 11 shows the crucial phases of industrial textile upcycling and their dependency on the four influencing factors (plus deterioration which affects all of them). Assigned to each of the crucial phases are indicators or pre-requisites; that refer to the factors of influence. These conditions have to be met in order to enable the functioning of the supply chain of industrial upcycling. A number of reasons that might lead to these indicators not being met and that would explain the lack of upcycling companies processing PCTW from industrial recycling companies have been described above.

The results of the empirical inquiry will be described according to the crucial phases, considering the influencing factors within each phase. However, in order to complete the picture and provide room for the occurrence of unexpected influencing factors and issues; the rather broadly defined (success) indicators will also be considered when analysing the data.

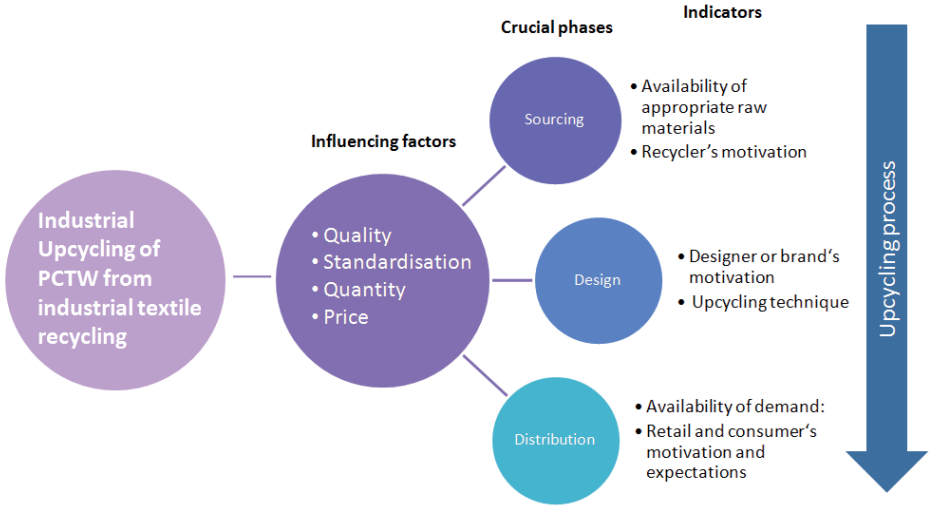


Fig. 12: Crucial supply chain phases of upcycling, influencing factors and indicators

6. Methodology of empirical inquiry and results

6.1. Type of the inquiry and method of interpretation

The aim of this inquiry is to identify the process of upcycling in business practice and to describe the challenges that industrial upcycling companies face when using PCTW from industrial textile recycling companies. Based on the findings, potential approaches to facilitate the use of this type of textile waste will be developed in order to promote co-operations between industrial upcycling and recycling companies.

The nature of this research study suggests the application of a qualitative method of inquiry. The reconstruction of the supply chain, mechanisms and

influencing factors that cause challenges related to the use of PCTW, require a non-standardized approach that allows identifying all relevant stages and aspects in the first place. This is only feasible using qualitative research methods that enable identification of complex causalities and their scope (cp. Gläser & Laudel 2009, p. 27-28). Qualitative research methods focus on capturing a complex problem in its various dimensions and, in doing so, allow reconstruction of correlations, decisions and background information (cp. Mayring 2002, p. 42). In this case, due to the lack of scientific literature on upcycling, the amount of unknown information that has to be gathered is expected to be high. As the inquiry is concerned with challenges in upcycling practice, the need to capture case-specific information is also considered high.

There are different forms of gathering data in qualitative research. The above described requirements make guided interviews with experts on PCTW upcycling and recycling the most appropriate technique of data collection. Guided interviews, where a number of predefined, but open questions are asked, are a form of collecting data with a certain degree of standardisation, while also providing flexibility for both parties involved (cp. Gläser & Laudel 2009, p. 41-42). The interviewee is free in terms of how and what to answer to open questions, and the interviewer is free in rearranging the order of the questions and in asking spontaneous requests, which only enables both parties to answer a question holistically. Guided interviews are suitable if, due to the aims of the study, different topics have to be addressed in an interview while also specific information has to be gathered (cp. ibid., p. 111). In this inquiry the supply chain of upcycling, as well as specific issues relating to the use of PCTW in industrial upcycling, build the concrete subjects of interest. Hence, this technique is suitable in this case. As this thesis aims to propose options to improve the use of post-consumer textiles in industrial upcycling, both industrially operating upcycling and recycling companies that process this type of material represent the most appropriate examination objects. Only they can provide information specific enough to elaborate approaches to promote the use of PCTW in industrial upcycling, which makes them experts in this context.

As a method of interpreting the inquiry's results, the qualitative content analysis according to Gläser & Laudel (2009) has been selected. The theoretical pre-considerations, i.e. the model of the supply chain of textile upcycling, the choice of influencing factors and the potential issues of upcycling PCTW, are based on few available pieces of literature on textile upcycling only. Furthermore, both the supply chain of garment production as well as the supply chain of textile recycling are very complex and depend on a variety of interrelating factors. Correspondingly, the supply chain model of upcycling, influencing factors and potential issues bear a high degree of uncertainty. In this case, the qualitative content analysis according to Gläser and Laudel is very suitable insofar, as it provides a high degree of flexibility of analysis, while at the same time, following a planned procedure. The extraction of information is mainly guided by the aim to answer the proposed research question. It is on the one hand based on a search pattern, i.e. a number of categories and influencing factors, that have been developed in the theoretical pre-considerations (cp. Gläser & Laudel 2009, p. 200). This secures them the role of guiding the selection of information and helping to answer the research question (cp. ibid., p. 201). However, at the same time the system of categories is open, it can be adapted within the process of information extraction, e.g. new categories can be added, and dimensions of existing categories can be changed. This also allows to make use of information that could not be anticipated, but is relevant for answering the research question (cp. ibid.).

The supply chain of upcycling and its differences to regular textile production build one category of the search pattern. The crucial supply chain phases (sourcing, design and distribution), including their potential issues, build the other categories. The influencing factors are relevant insofar, as they affect both the supply chain as such and especially the crucial phases. They also affect

the (success) indicators named for each of the crucial supply chain phases, but they will not be considered categories of their own. They are only relevant and thus considered with regard to their impacts on the supply chain, its crucial phases and the success indicators. The role of the success indicators as broadly defined pre-conditions that have to be met in order to enable industrial PCTW upcycling is to allow the integration of relevant data that might not be covered by or be directly related to the main influencing factors. Based on this open system of categories, the relevant information required to elaborate solution approaches to improve the use of PCTW and promote the co-operation between upcyclers and recyclers can be extracted.

6.2. Selection of interview partners and structure of guidelines

The study aims to identify issues in upcycling post-consumer textile waste from recycling companies and aims to promote the co-operation between recycling and upcycling companies. Industrial recyclers and industrial[78] upcyclers that already work with PCTW and co-operate with textile recycling companies have been selected as most promising interview partners. While the selection of textile recycling companies as interview partners is obvious, as they represent potential suppliers, the reason to choose only upcycling companies that fulfil the above mentioned criteria is based on their experience and therefore their potential to provide detailed information on the issues of upcycling PCTW from recyclers.

As classic industrial recycling companies usually operate in a similar way, the focus of the inquiry was placed on upcycling companies. In total, three interviews were conducted (two upcycling companies, one recycling company). One potential interview partner from the field of upcycling could be identified in a publication on textile upcycling (cp. Redress 2013b), another by visiting a fair for sustainable textiles (Innatex). The literature-based research, as well as an internet-based research performed, obtained the result that currently there seem to be only two industrially operating upcycling companies worldwide that source from textile recycling companies.[79] As both of the upcycling companies are located abroad, the interviews were conducted in English via video call and recorded on tape. As recording failed when interviewing Upcycler 2, memory minutes were taken and based on this document, the interview was repeated, which allowed to verify the correctness of the data comprehended and also to follow up on some of the findings. This second interview was recorded and transcribed. The industrial recycling company was selected due to its size and presence in several countries and various continents. This allows considering the situation of textile recycling and the issues related to upcycling on a global level. The interview was conducted in German, but due to the geographical distance to the company's head office video call was also used. By the end of the interview, the call was interrupted and could not immediately be resumed, so the interview was finished a few days later.

The interview guideline for upcycling companies is structured according to sections 5.4. and 5.5., so there are two main parts. The first part focuses on identifying the supply chain of industrial textile upcycling and the differences to virgin textile production. The second part specifically deals with challenges and the motivation of suppliers, designers and consumers to involve respectively buy upcycled textiles. The interview guideline has been marginally adapted for each of the two interview partners using information that their websites provided. As the recycling company mainly provides information on supply of PCTW, the guidelines designed are based on the four influencing factors:

78 The companies might not yet produce on an industrial scale, but due to operating in a standardised way, they can still be considered industrial upcyclers.

79 A number of other industrial upcycling companies are mentioned in section 5.3.

standardisation, quality, quantity and price, as well as the overall motivation of a company to involve in upcycling. The guidelines can be found in Annex 1 together with the memory minutes of interview 2.

6.3. Results

In this section, the results of the empirical inquiry are presented. Based on the information provided in the interviews, section 6.3.1. depicts the supply chain of industrial textile upcycling of PCTW and describes the differences to regular garment production. Subsequently, in section 6.3.2., the challenges mentioned by the interview partners, referring to the crucial phases of the supply chain and between the various actors, are outlined.

6.3.1. The supply chain of industrial textile upcycling (of PCTW)

The supply chain of industrial upcycling as described by the interview partners basically corresponds with the model developed in section 5.4., which is why at least the main phases can be adopted as they stand. The only variation occurs between the first phases, i.e. market communication, sourcing and design. These are not necessarily chronologically determined in industrial upcycling, they are rather interdependent and influence one another [U2–34].[80] As regards the necessity of the processing steps (the ones assigned to sourcing and production) or rather the effort they require in production, the supply chain cannot be generalised, due to the non-standardised input material [U1–14]. The generic supply chain of industrial upcycling is depicted below[81]:

* Sourcing includes checking/grading/sorting and storage of material
** Production includes disassembly and reassembly and prior cleaning and colouring if necessary

Fig. 13: The supply chain of industrial upcycling (of PCTW)

The relevant processes, that the upcycling companies described, are explained in the following:
Like in regular fashion production, fashion trends also play a role in upcycling, but the starting point is the material that the company has been or will be supplied with or which it has on stock [U1–10]. According to Upcycler 1 [16] this determines the designs and even the products that can be made from them:

> "Everything starts from the materials. Having some materials that you can use (…). Then the next step is actually designing some products from these materials."

On the other hand, when sourcing material, the designer usually already has some materials or design ideas in mind and typically a collection also follows a theme, so the materials and designs have to reflect this theme somehow [U1–16]. Hence, sourcing and design are interrelated [U–34]:

> "It's interrelated, hand-in-hand. Completely. It's what you can get and also what you want to do with what you got."

80 As will be seen later on, this is, however, based on the upcycling companies using a set of strategies to standardise sourcing and therefore making the design phase more independent.

81 Although this thesis deals with industrial upcycling of PCTW, the model was developed rather generically. According to the answers given by the interview partner, it was found that in practice, the supply chain steps do not differ for the various types of textile waste (only production waste does not have to be unpicked). Thus, the model describes the supply chain of upcycling in general.

Based on the available textile materials, the design phase comprises the development of models, the patterning, test colourings and washings[82] and the instructions for production [U1–16]. These are typical steps in textiles and garment production. However, as had been assumed[83], development of models is more complex in industrial upcycling [ibid.]:

> "Then you go into designing and there you look at different kinds of materials you have. And this is a little, we do quite a bit mixing and matching, taking pieces from here and there, thinking (...) how do you use all parts of that jacket without creating a lot of additional waste and really how you most efficiently use the materials? How do you still make it interesting with details? At the same time making it producible in large quantities, so that you have good pattern and everything and if you can repetitively make it."

After designing, samples are produced and the models can be pre-ordered, which is comparable to the usual textile and garment production cycles [ibid.]. After pre-orders are taken, materials are ordered and six month after designing, production starts [ibid.]. In the case of Upcycler 1 [24], until then the materials that are taken directly from suppliers have been on stock, other materials that they know they can always get, are kept in samples. Upcycler 1 [76] has a rather big storage, which is considered necessary and even advantageous, as the samples stored are required for designing and as production requires detailed sorting into many categories in advance, there has to be enough space.
The materials have to be sorted when they arrive, some of them have to be washed, because they are dirty, but often they are clean [U1–86]. The PCTW sourced from textile recycling companies usually arrives pre-sorted and pre-washed [ibid.]. Sorting, however, does not only refer to whether the materials have to be washed, it also refers to aspects of colour, fabric type, thickness of material and also based on what kind of products they can be used for [ibid.]. When sorting, the items that are similar and match nicely have to be put together, and the quality of the fabric has to be checked [U1–44]. This kind of extensive sorting does not have to be performed in regular textile production as the fabric comes on meters [ibid.].

Upcycler 2 has to wash the material they source from textile recycling companies, but not all of it, as sometimes the materials are very clean [U2–40]. Their sorting process is not as complex as the sorting process of Upcycler 1, as they only source very specific fabrics in specific colours and do not have a portfolio as diversified as Upcycler 1. Upcycler 2 re-sorts the materials at the recycling company's site and only buys the ones that are suitable [U2–30]:

> "We go to a textile recycling factory, we give them a list of what we want. We go through it, because of even they're asked for the wools, and the cashmeres and the merinos, you get acrylics and you know jumpers that we can't use so we have to re-go through everything".

Upcycler 1 sometimes also colours the recycled textiles, but only to make the collection more interesting [U1–102]. Upcycler 2 does not colour [U2–40].[84] Upcycler 1 [26] does test-colourings and washings within the design phase and after the pre-orders are taken and actual production starts, the materials are washed if necessary, and coloured if wanted. Production also includes collecting

82 Colouring and washing is not a standard procedure. Only some of the materials that Upcycler 1 processes are coloured, and washing is only done if necessary [U1–102].
83 Cp. section 5.5.2.
84 Colouring was not considered as a potentially relevant processing step. However, it is only done with some of the material.

the materials from the warehouse, putting them together and then they are sent to production. Both upcycling companies have outsourced production. Upcycler 2 [44] even works with a subcontractor who is situated abroad, but this is only possible as the production co-ordinator has worked with them for a long time. Upcycler 1 [72] outsourced colouring, unpicking, cutting and sewing. Upcycler 2, initially only outsourced sewing, later on cutting was outsourced too [U2–46]. Production comprises unpicking, cutting and sewing. Unpicking is an additional production step that does not have to be performed at all in regular textile production [U1–44]. Cutting has to be done individually, one by one rather than in bulk which makes the process more expensive [U2–54].[85] And, usually, sewing companies do not provide the resources like space and personnel to unpick and cut individually which makes it hard to find appropriate partners [U1–44]. After sewing the products are shipped out [U2–30].

Differences to regular textile production

The description has shown that the supply chain of industrial upcycling of PCTW is similar to the regular supply chain of textile and garment production in many parts. There are, however, two main deviations:

1. Compared to regular textile production, in industrial PCTW upcycling, design is dependent on the material available. This makes designing more complex and challenging, especially for industrial production, as models have to be standardised [U1–16].

Both upcycling companies follow the strategy of only using specific textiles from the recyclers they co-operate with, comparable to the approach of Fraser as described in section 5.4.1.: Upcycler 1 sources certain types of home textiles, certain fabrics and types of garment [U1–50, 62]. Upcycler 2 sources specific fabrics (fibre types) and types of knitwear in common colours [U2–32]. This strategy facilitates the process of designing and enables standardisation and serial production: Designing is not entirely dependent on the (physical availability of) material sourced, which creates the state of "interrelatedness". The models can be developed before actual sourcing, which reduces complexity for the designer. The strategy also increases standardisation of input, production and eventually products.

2. There are a number of extra tasks in industrial PCTW upcycling:

The study confirmed that checking and sorting of raw material, usually, does not have to be performed and can also be complex in upcycling, as, for example, in the case of Upcycler 1. Checking and sorting is a complex process which requires the availability of a large storage facility, as the company uses all types of textile waste (production waste, pre-consumer and post-consumer waste), generally processes a broad range of different materials and its portfolio is diversified. In the case of Upcycler 2 who only uses very specific textiles from recycling companies and processes it together with organic (virgin) and recycled meter fabrics, the need to sort and store the material is lower.
Cleaning is not always necessary, but unlike assumed, the step cannot be easily skipped. Upcycler 1 underlined that this is not so much a processing step that only refers to post-consumer material, but rather to upcycling in general as they sometimes also have to clean production and pre-consumer waste [U1–102].[86] On the other hand, washing can also be a means of quality management or part of the strategy. Some materials have to be washed, because they might

85 Compare the manufacturing process model of Fraser (2009) in section 5.4.1.

86 It was assumed that production waste and pre-consumer waste, due to not being used, do not or very seldomly have to be cleaned and this process could be skipped.

shrink. Usually the material has, however, been washed many times before, so this is not a problem [U1–26] and sometimes materials are washed because they are supposed to shrink [U1–102].

Another additional step is disassembly. Both upcyclers disassemble their materials before processing. Hence, they concentrate on reconfiguration as upcycling techniques. This disproves the presumption that upcyclers might involve in PCTW upcycling, because it allows to apply all other upcycling techniques apart from patchworking and reconfiguration.[87] Unpicking and individual cutting are further steps in upcycling that do either not exist in regular production or can be rationalised.[88] This makes the process of upcycling more costly compared to production based on meter fabric and, according to Upcycler 1, they do not achieve significant economies of scale, as the production process cannot be rationalised [U1–32]:

> "We don't get economies of scale. Not really, because it's handmade. In handmade production you don't really get very big economies of scale. Of course, the bigger the quantity you'll only get one shipment, and then there is a certain kind of cost for ourselves to kind of managing the production. But the production cost per item doesn't really change whether we do ten, hundred or thousand. It is handmade. A person can do exactly within the same time, no matter if it's a one or a thousand."

3. Outsourcing of production requires partners to have specific resources. When outsourcing production, i.e. especially unpicking and cutting, at first they could not find partners that could provide enough space and personnel to do it [U1–44]. Cutting from meter fabric does not require space and staff to unpick and cutting is a multi-layer, standardised process. As a result, the strategic relevance of the production process (and of partners) is higher compared to usual production.[89]

The lack of achieving economies of scale might be owed to fact, that both upcycling companies cannot yet be considered industrial companies in the sense of producing high amounts of textiles (thousands of pieces of the same model), which is a pre-requisite for achieving economies of scale. They are rather industrialised in the sense of producing standardised designs in a standardised way, in medium quantities (hundreds) though [U1–16, U2–16]. However, disassembly could only be skipped by applying other upcycling techniques such as embellishment or combination. If those designs and the production could be standardised, it might be possible to produce higher volumes and achieve economies of scale as well.

6.3.2. Challenges in upcycling PCTW from textile recycling companies

In the following, the challenges that were mentioned in the empirical study are described. Due to the complexity of the matter, the research project only depicts challenges that refer to the previously defined crucial phases of upcycling. The main challenges occur in the sourcing and design phase, this is partly owed to the fact that both processes are strongly intertwined. Due to this fact, and in order to reduce complexity, most of the aspects referring to the design phase are already regarded in the sourcing phase. As a result the design phase primarily considers the motivation of designer/brands to involve in upcycling.

87 Compare section 5.3.

88 Non-standardised pattern placement has not been mentioned as characteristics specific to upcycling.

89 Compare Grandke 1999, p. 75 in section 3.3. In section 5.4.3. it had been assumed that the role of producing partners would be comparatively low.

6.3.2.1. Sourcing

Subsequently, the insights gained regarding the different influencing factors are described according to both parties (upcyclers and recycler). At the beginning of each section, each case, the business model, its aims and motivation are briefly described.

6.3.2.1.1. Upcyclers

Until recently, Upcycler 1 only used waste textiles as input for production. In order to be able to produce basic products, like t-shirts in standardised colours, they have added organic cotton as a raw material [U1–4, 6]. Upcycler 1 had been founded already several years ago and since then they have built a broad network of supply for the various types of materials they source.

Post-consumer textiles from households are sourced domestically from a few sorting companies that regularly supply the company with specific materials as described in the previous section [U1–50]. Upcycler 1 does not use large amounts of production waste as raw materials, as there is only little textile and garment industry in the country they are situated in[U1–58]. The company tries to source and produce locally to minimise logistics, however, some materials that they cannot source in their country, are sourced abroad [U1–66, 68].

Upcycler 2 only uses post-consumer waste from textile recycling companies (arans, jumpers, cashmere, wool and merino in specific colours). They, specifically, source garments that are no longer wearable and would otherwise be shredded. The fabric is processed with virgin and other recycled meter fabrics [U2–30]. In the beginning, the company only used 100 % recycled textiles, but in order to be able to standardise quality and production and be less restricted (more creative), they decided to mix recycled with virgin, resp. meter fabric[U2–72].The company co-operates with two textile recycling companies in their country of origin.

Standardisation

As described above, both companies source specific textiles from recycling companies, which is one strategy to standardise sourcing and production.

Upcycler 1 sources a number of different products, curtains, lace, jeans, leather, and men's suits [U1–62]. These are mainly used for bags, but sometimes also for garments, e.g. as lining [ibid.]. They are usually satisfied with the materials they are allocated by the recyclers, which they explain by the long time they have been collaborating with their partners, so they have already learned what the company can process and what is not suitable [U1–62, 96].[90] However, the evaluation of non-standardised material in terms of suitability is based on a personal opinion, so according to Upcycler 1 there are limits to process optimisation due to the non-standardisation of the material:

> "Or like holes. Because it's always specific case by case, so it's always a personal judgement, also from our subcontractors. So, of course, sometimes we disagree. But that just happens. So you cannot totally avoid it, but I would say really mostly it all goes well. And it depends on the longer you have worked with the partner the better it gets, because the more they get to know you and really understand and can start imagining how does it kind of impact the quality of the end product." [U1–100].

90 Here, the strategic relevance of sourcing and sourcing partners in order to minimise transaction costs, becomes clear.

Upcycler 2 generally re-sorts the materials at the recycling site before they buy them. They do not always or only get the materials sorted out that they usually order:

> "We go through it, because of even they're asked for the wools, and the cashmeres and the merinos, you get acrylics and you know jumpers that we can't use so we have to re-go through everything, hand pick through it to make sure we get in the good stuff" [U2–30]. "Because generally what they collect for us we take about third or less of it, a quarter of it, because the rest of it is just not good enough" [U2–32]. "We don't use any acrylic jumpers or stuff like that, we only use those cashmeres and wools and merinos. But occasionally you know you do get one bag and it's pure wool, but it looks just a little bit old any you know that when it's on a garment so next to new fabric on a hanger in a shop it's just not going to look perfect enough". [U2–14].

On top of sorting being an extra step in the process, upcycling of PCTW requires proper sorting. This refers to the deterioration characteristics of a textile, but also to the types of materials. As can be seen in the case of Upcycler 1, intensity and duration of co-operation helps to improve the efficiency of the process, but due to being based on a personal judgement, there are limits to this optimisation potential.

Another issue is the non-standardisation of colours, fabric, shape etc., which makes PCTW from recyclers unsuitable to use as main materials:

> "In large scale production, consumer recycled materials are more difficult to manage, because they naturally vary.[91] So what we do is they are better not used as main materials, but we rather use them as supporting, I mean, decorative materials" [U1–102].

Upcycler 1 only sources about 2 % of the total material they use from textile recycling companies [U1–62]. Upcycler 2 mixes with meter fabrics, because if they were only using PCTW, they could not keep the quality and standardise their production sufficiently [U2–71]. Production waste is considered advantageous in that case "as it comes in bigger quantities" and even pre-consumer waste, which is "different sizes, but (...) they are more of the same material and so it's more repetitive than from consumers, where you need to do a lot more sorting" [U1–102].[92] However, Upcycler 1 [86, 102] emphasised that in upcycling, respectively recycling in general, "everything is different", and that they do not usually think in categories of production, pre-consumer or post-consumer waste.

Non-standardisation (and deterioration) result in PCTW from recycling companies being more complex to process compared to other types of textile waste, mainly due to thorough sorting and unpicking. In general, there is optimisation potential and compatibility of sorting/sourcing is given, as both recycling and upcycling companies use the same or at least similar criteria to classify textiles (type of textile, material, degree of deterioration). Hence, sourcing is a crucial phase in upcycling of PCTW and in order to lift the full potential for process optimisation of sorting, respectively minimise redundancies, upcycling companies are required to consider recycling companies

91 "The materials vary a lot in terms of colour, quality and stuff like that. So making unified designs from other materials, from other sources, is easier, because there you get more of the same and of same quality." [U1–64].

92 The same accounts for post-consumer waste from institutional consumers such as uniforms or work wear. They also differ regarding sizes and deterioration, however they are also of the same material or colours even. See also section 5.5.1. or (cp. Aus 2011: 52).

strategic partners, rather than simple suppliers of raw materials and co-operate closely with them on a long-term basis.

Quality

Both partners mentioned that the quality of the material sourced is of great importance[93]: "You have to make sure that they [the materials] are high quality" [U1–16]. "Upcycled products have to be of high quality, because they have to last" [U1–104]. According to Upcycler 2, using high-quality materials is a pre-requisite to successful upcycling, because using low-quality and worn fabrics would not be worth the effort as in the shop on the hanger, next to virgin products, upcycled ones could not compete [U2–32]. Sourcing appropriate materials from textile recycling companies in sufficient amounts is a challenge to Upcycler 2: "The problem is finding enough good quality stuff, because so much of it is such crap quality you know it's not worth being reused" [ibid.]. The low quality is the reason why Upcycler 2 can only use one third or even a quarter of the materials that the recycling company sorts out for them and as a result they have to use materials that the company has a lot of [ibid.].

Quality of material mainly refers to the quality of fibres (type), fabric (strength), but also to the use marks of the fabric [U2–36]. Stains and holes are not so much of an issue as the products are cut in production and for Upcycler 1, the history of the fabric is "part of the story" [U1–96]. The fabric texture however, its "freshness" and colours are of importance "when it's on a garment, so next to new fabric on a hanger in a shop" [U2–14]. But especially its strength has to be suitable for reworking the material [ibid.].

Reworking, i.e. reconstructing (unpicking, cutting, sewing) is the upcycling technique both companies use. Embellishing might be more independent from fabric strength.

Price

Other than assumed, the price of sourcing raw materials from textile recyclers was not mentioned as an issue by either of the companies. In fact, Upcycler 2 follows the strategy to source high quality textiles, i.e. valuable fibres such as cashmere, merino and wool, that are not rewearable, so their value is lower. In that way cost benefits can be achieved:

"But you hope as well, your need, your motivation is using fabrics that have a higher value than you're buying them for. Wool is quite expensive to buy, therefore it's cost-effective for us to buy in cheaper spending extra time on it. We probably don't save ourselves any money by upcycling, it probably costs about the same in the end, maybe slightly more." [U2–54].

Quantity

A lack of quantities as an issue in supply (of high quality textiles) has only been mentioned with regard to the lack of quality: "The problem is finding enough good quality stuff, because so much of it is such crap quality" [U2–32].[94]

Summary

Both industrial upcycling companies require high amounts of high-quality, standardised material. As they reconfigure the textiles material strength has to be sufficient. Main challenges are the lack of standardisation of PCTW from recyclers and to receive sufficient quantities in a good quality. Moreover, mainly due to the lack of standardisation, the processing is complex and requires a lot of effort.

Both companies have already adopted a range of strategies in order to be able to process post-consumer textiles in an industrial way: In order to secure supply, they only source parts of the materials they need for production from

93 See section 5.4.3. and 5.5.1.

94 Compare section 5.5.1. or Aus (2011: 50).

sorting companies. This allows them to vary the share of PCTW in their textile products and increases independence from material flows from this source. Furthermore, both companies co-operate with more than one recycler and only source rather commonly available materials or colours, which increases the available amounts per season.

In order to increase standardisation, they source specific materials from textile recycling. Upcycler 1 sources rather commonly available textiles and the portfolio of Upcycler 1 is diversified (garments, bags, accessories, shoes, etc.), which allows them to use a specific material for more than one purpose. Curtains for instance are used for bags and accessories, but sometimes also for clothing [U1–62].[95] In that way criteria for sourcing are not too restrictive, as a fabric unsuitable for garment production can still be suitable for producing bags. On top of that, waste production can be minimised as pieces of fabric too small for garments can still be used for pouches. The company also has a large storage of materials, so they are not solely dependent on the inflow within one season. Upcycler 2 sources specific and only high-quality materials from recyclers. This limits the amounts of material available and might be the reason why they have issues in finding enough appropriate raw materials.

This development of strategies that allow for serial upcycling of PCTW has not yet been known in upcycling literature.

95 What use the material is appropriate for depends on its characteristics. "(…) well a curtain then, we categorize them by the type of the fabric: kind of thicker, thinner, fancy, standard kind of thing. So we categorize them a little bit, so we could use the really fancy type of curtains in dresses, and then we could use the simple kind of kitchen curtains and the linings for the bags." [U1–86].

6.3.2.1.2. Recycler

The recycling company interviewed is a global player in textile recycling with a number of branches in different countries. The company is vertically integrated: it collects, sorts and recycles. Textiles are usually divided into three fractions: rewearable textiles which are second hand textiles for domestic and international markets, wipers and feathers who need to be minimally processed and can then be sold. The third fraction is the actual recycling fraction which is mainly fleeces and other products for the automotive and building industry. The textiles destined for second hand use are again divided into "creme", first, second, and third quality. Whether second hand products are "creme", first, second, or third quality mainly depends on the degree of deterioration, hence "creme", basically, applies to new products while those sorted into other categories are more worn out [R–14, 16]. Second hand clothing makes about 60 % of the collected textiles, the remaining 40 % non-rewearable fraction consists of wipers/feathers and recycling materials. The company is interested in innovative concepts of recycling and upcycling, as the global second hand market is changing and the amount of rewearable fractions is decreasing. This is however, not primarily due to the supply side, e.g. a decreasing quality of textiles which might lead to less collected garments being rewearable, but rather to the markets becoming more and more mature and therefore demanding: Several years ago, rewearable textiles made 70-80 % of collected materials; today, it is only 60 % and this percentage will further decrease due to people in developing countries having more and more spending power and markets coming to maturity. Countries that used to buy second and third quality are already now demanding first quality or even "creme". Other countries like Russia for example have imposed import tariffs which makes selling of cheaper qualities uneconomical. For those reasons, recyclers are looking for profitable alternatives [R–8, 10]. Especially closed-loop textile recycling without decrease

in quality is considered promising, as to them the future of the textile industry is circular and they want to become the supplier of secondary raw materials to the textile industry. [R–2, 3]. However, for new technologies or concepts to be interesting, they have to be scalable and allow multiple or infinite recycling. Apart from post-consumer textiles, the company also processes pre-consumer waste, i.e. sales leftovers, but they do not process production waste [R–71].

According to the interview partner, the company is no longer interested or at least not focussing on fashion upcycling anymore, they are now focussing mainly on chemical recycling, which they consider more promising, as the technique can process mixed fibres of any composition (in contrast to mechanical and physical recycling), hence the requirements are lower and the result is claimed by chemical recyclers to be of equal quality compared to virgin materials [R–20]. The reasons why the company doesn't see a great potential in focusing on "high fashion upcycling" as they call it, are manifold, but mainly refer to the category of "quantity".

Quantity

In general, it is easier for a sorting company to think and work in fibre material categories, i.e. cotton, polyester, etc., and provide the textile industry with secondary raw materials that they can use for any kind of product they want to create. In this way they can process huge amounts of textiles to secondary raw material. [R–24].

Fashion upcycling is limited to the amounts of materials available and upcyclers only find certain types of textiles, e.g. t-shirts or men's suits, suitable for fashion upcycling. This limits the opportunity to mass produce and even they (as a global player in textile waste sorting) reach their limit fast [R–24]. The insights are based on experiences from the past: A few years ago the company partnered a designer with whom they produced and marketed upcycled garments from various types of PCTW (e.g. leather, jackets, t-shirts). As the designer had developed models for celebrities in the past, the collection was very well accepted by the market. Some major department stores adopted the collection and demand continuously increased. Production was supplied by the local sorting facility, but with increasing demand the plant had soon reached its potential and they ran out of raw materials for supply. At first they'd sent additional materials from another sorting plant to make good the deficit, but it was still not enough. Eventually they stopped the project, because processing was not standardised enough and therefore too complex, too expensive and the amount of material they could upcycle in that way was too small compared to the amounts they annually process. [R–26].[96] This was insofar an issue, as the basic requirement of a large recycling company like the one interviewed, is that a distribution channel is able to process several thousand tons of material per year in order for them to make a difference. For smaller companies, it might be more interesting. For them however, fashion upcycling, the way it has been performed up to now (as a high fashion approach) has failed to be so so, because it was not scalable in the sense of becoming an industrial sector. [R–28, 30].

Being able to sell large quantities to a customer or business segment represents the main motivation of recycling companies to enter markets.

Standardisation

The lack of standardisation the recycler criticised is based on the upcycling technique the designer they partnered used. Their approach was to rework

96 Upcycler 2 [32] also stated, that their partnership with one recycling companies is based on the good relationship they have: "So we would, because we have a long history with them, we still work with them, but it would be quite difficult for us to find another textile company that would put that amount of stuff for us and then we take such a small amount of it." For the other company they work with, the partnership is also financially interesting, as the upcycler buys materials that would otherwise probably have been shredded, at a higher price and the material has already been graded through [U2–64].

(reconstruct) the products entirely: They used for instance old leather jackets and sewed them to jackets again and they used men's jackets and produced dresses and vests [R–30]. The processing lacked standardisation, was labour-intense and furthermore produced high amounts of textile waste (at least 50 % of the original material) [R–32]. They say that as soon as a recycling technology is standardised and allows them to sell large amounts it will become interesting to them [R–56].

The recycling company has co-operated with one second hand shop owner who also upcycles textiles and tries to scale up production for many years already. This partner tries to minimise processing by only using a few handgrips: T-shirts for example are only minimally altered, they are not unpicked and cut, but only re-sewn to become a lady's top. They also produce bags from cargo pants. Both side pockets are cut out with some extra fabric and together with leather from old jackets, they are sewn to become a tote bag. In that way processing is minimised and standardised. [R–48].

This way of upcycling, which is no longer high fashion production, but rather simple reconstruction and embellishment, is considered more promising by the recycling company. It represents something between industrial upcycling in the sense of chemical recycling and high fashion upcycling which is limited to a certain, relatively low amount of textiles produced [R–38].

Some years ago the same partner has produced a roll of fabric from textile waste. The fabric was sewed together using pieces of fabric with same or similar patterns. The project was very successful and demand for the rolls was high, as afterwards it can be processed by a brand according to their specific wishes. [R–48].

Due to the complexity, non-standardisation of processing and the high costs, the recycling company does not consider reconstruction of PCTW a promising strategy that allows upcycling on an industrial scale. However, their partner exclusively used PCTW, whereas the upcycling companies interviewed mix with other materials in order to increase standardisation, the limits of scale are not yet reached, at least for Upcycler 2 [16]. Upcyclers could however, start looking into options to embellish or only minimally alter PCTW in order to minimise processing costs.

Quality

Another issue in fashion upcycling, is that the materials upcycling companies want to source, are very specific and often high quality products or fabrics from rewearable fractions (creme, first, second, third quality). Even though upcyclers usually only want to source very few amounts, co-operations fail, because their choice of material affects a certain quality or key product to the sorter' customers. This means that for specific markets or customers there are products that have to be included. If these key products are no longer included in a batch, because they are now bought and processed by upcycling companies, second hand traders are unsatisfied with what they would receive and the recycler threatens to not be able to sell the remaining huge amounts of textiles that would then have to be shredded. [R–46]. As a result they might have sold e.g. 5 tons of Polo Shirts, but they might not have been able to sell the remaining 500 tons of other textiles which would also affect economics [R–64]. Hence, upcycling companies either have to process the "entire batch", or only source products that are not key to other customers [R–69]. In general, the arrangement between both companies is very important. According to the recycler, before designing, upcycling companies should co-operate closely with recycling companies in order to know what kinds of materials they can offer in bulk without negatively affecting other sales channels.[97] This allows process optimisations for both types of companies.

The second hand trader/upcycler they co-operate with knows the industry

97 The statement indicates that up to now upcyclers have not been considering recyclers strategic partners.

and the materials recyclers process as he has worked in the recycling industry for a long time already. Therefore, this customer only sources textiles that are available in abundance like for example jeans/denim, t-shirts, jackets (from men's suits), etc. They do not source materials such as 100% cashmere pullovers, as they know well that a sorter has only very limited amounts of such material and other customers also wantto purchase such items.[98]

Both upcycling companies have already partly adapted their sourcing strategies to these circumstances. Upcycler 1 sources textiles that recyclers process a lot, among others jeans and men's suits. Upcycler 2 sources valuable and rather scarce fabrics such as cashmere and merino. In order to compensate for that, they source common colours such as black or grey. For ideological reasons, Upcycler 2 only uses non-rewearable textiles that would be shredded otherwise; hence, their material choice does not compete with second hand customers. However, the existence of key products not only affects second hand reuse, but also the wiper market for example [ibid.]. So, sourcing non-rewearable fractions might not be a sufficient strategy to overcome the problem. The role of opportunity costs differs from what had been expected initially: opportunity costs refer rather to quantities and certain product categories than to price in general.

Price (and Quantity)

A recycler can charge higher prices to upcyclers, as the value generation of upcycling is higher than in case of second hand reuse for example. In that way, the recycler can maximise profit for those certain products upcyclers buy. However, in the set-up as described above –where certain qualities or key products are taken by upcyclers and the recycling company is not able to sell other major fractions– it subjects the recycler to worse economic conditions. According to the interview partner, sorters do not really care whom they sell their material to, they are interested in selling as much as possible of the materials they process, so in the end the correct calculation decides [ibid.].

The motivation of recyclers regarding the environment is again based on quantity rather than quality.

Summary

Recycling respectively sorting companies process huge amounts of textile waste and turn them into complex product batches for a number of different markets. Their main motivation is to sell as many textiles as possible. In order to minimise downcycling, they create batches of more and less attractive products for the various markets. As sales markets for lower quality second hand textiles increasingly break away, they have to find new, valuable recycling options. Chemical recycling is what they consider most promising, as recycling according to fibre type is easier, especially for chemical recycling which, in case the technology will be ready for the market within the next years, allows them to process high amounts of materials in that way. Fashion upcycling up to now has failed to be an attractive sales market to them, as the business model of upcycling companies is based on a high fashion approach, i.e. sourcing high quality textiles and reworking them in a labour-intense process. Due to aiming at only creating a very limited number of textiles per model, demand on behalf of upcyclers is too low. Furthermore, upcycling companies only demand specific textiles that threaten to conflict with other product categories, which can lead to the recycler not being able to sell the remaining larger fractions. This eventually affects the sorter's overall calculations. In that way, textile recycling and fashion upcycling are incompatible.

98 The recycler referred to rewearable products in that section. For non-rewearable products this might be different.

6.3.2.2. Design

Upcycler 1 and 2 both use recycled materials for environmental reasons. Upcycling company 1, which uses all kinds of textile waste, was established, because the founder thought that there is too much waste in the world, so her primary motivation was to use only existing materials [U1–2]. Upcycler 2 only uses post-consumer textiles, because they consider it the most environmentally-friendly material [U2–38]. They would also work with other types of textile waste (pre-consumer and production waste) by partnering large fashion brands, but they found it hard to find partners that want to work with them.[99] The reason is, because the supply chain of large fashion brands is so complex that they do not even know where textile waste accumulates in what amounts and because their designers do not have experience in working with textile waste and don't know how to be able to use the material in mass production [U2–16]. Although brands know they will have to deal with the issue of waste production, the recent economic recession has led them to think upcycling is a project too risky to invest in now [ibid.]. Furthermore, if a company wants to convey a sustainable message, there are easier ways to do so by using (virgin) fair-trade or organic meter fabrics, which also have a clean, clear message, whereas textile waste is often perceived as "dirty" [U2–18]. However, in general, interest in upcycling is continuing to increase and more and more brands are starting looking into it [U2–12, 70].

The need of experience for designers when working with waste is based on the fact, that upcycling is more challenging than production from meter fabrics, as the material is non-standardised and naturally varies [U1–102]. In industrial production, the designer also has to make sure that a model can be produced in series [U1–16]. Furthermore, upcycled textiles, have to be designed well, priced correctly and the material used has to be of high quality [U1–104]. Having a good design and using high-quality fabrics is considered crucial by Upcycler 2, as the products will have to compete with virgin textiles when sold in a shop [U2–14]. Upcycling, being more challenging than regular production, is another reasons why Upcycler 2 works with textile waste [U2–18]. To Upcycler 2, upcycling does not limit creativity, upcycling challenges it. This is, however, a very personal attitude. Other designers, who work with recycled materials, might just design-wise not prefer PCTW, because according to Upcycler 1, "sometimes the idea for the product comes from the material to 100%. Like the shape of some of our pouches is round, because we know that we get a lot of navy sacks which have a round bottom, and we need to figure out a way to use it, so we started making round pouches." [U1–88]. Upcycler 2 mixes virgin and recycled, because upcycling from 100 % recycled (PCTW) material is very restrictive, "you can't really produce a good design, it's so restrictive, it restricts the design process as well and it restricts what you can make" [U2–70]. Another limitation of upcycling is that some products, for example simple t-shirts of a certain colour, can be serially produced from textile waste only with difficulty. For that reason Upcycler 1 recently started using organic cotton for some products, that they could not produce up to now. The aim is to make the collection more complete in terms of variety of products [U1–8, 10].

Both upcycling companies interviewed entirely rework the textiles they use, i.e. they use reconfiguration as upcycling techniques. This makes the process of upcycling more costly and requires the use of high-quality raw materials.

Apart from recycling companies, upcyclers might generally find it hard to identify and convince companies to supply them with waste material. Providers (fashion brands) are often also not interested in having their textile waste recycled. A general challenge of upcycling is, that this concept of sustainable fashion design is not as easily adoptable as other approaches to sustainability

99 Due to higher opportunity costs for disposing of waste, it had been assumed that fashion brands are motivated in partnering upcyclers (see section 5.5.1.).

in textile production. The amounts of material available are limited and due to non-standardisation, the design process is more complex and requires experience to work with. Furthermore production is more costly, although this again relates to the upcycling technique used. Hence, in contrast to what had been expected, upcycled textiles have to compete with alternative approaches to sustainable textile production rather than with other types of textile waste in upcycling.

6.3.2.3. Distribution

In the marketplace, upcycled products have to compete with virgin products, especially with other sustainable textiles. According to Upcycler 2, a major problem in marketing upcycled textiles is that there is no market segment for upcycled products [U2–10]:

> "I find it a little bit problematic talking about the upcycling textiles market, because I don't really think there is a consumer market who specifically goes out to buy upcycled textiles, I think it just happens to buy because they like the design (...). There is a consumer market that goes out to buy sustainable or looks to buy sustainable, you know prefers to buy sustainable, that's a definite market, but I don't think there is a specific market for recycling. Occasionally, maybe if somebody is so into it, who wants to buy it, but it's such a small number of people. I would say it's probably not even (...) worth to sort of identify them, yet, maybe in the future there will be more."

Apart from the fact, that upcycled garments have to share the sustainable textiles market with all other approaches to sustainable production, upcycled products have the "disadvantage" of being produced from waste material which is often associated with "dirty". Hence, deterioration, or just the fact that products might have been used before, can hinder market acceptance. Another problem is that upcycled is often equated with "poorly designed", because especially in the past, designs were poor.(This is getting better now). Thus, upcycling does not have a particularly compelling story to tell [U2–12]:

> "I would say that when we sell clothes, quite often I don't tell people that we're upcyclers. I don't quite think it actually helps sales. And I think that people don't like the thought that much, that it's made from waste. It's not of a particularly, it hasn't really got a sexy look to it, it hasn't got a very sexy image or desirable image. And that is something that we really as upcyclers try to combat".

As a result, they mainly market their products via the designs. Hence, a good design is crucial to them. Depending on the customer, i.e. the retailers, they sometimes do not even mention the fact that the garments are partly made from recycled textiles [ibid.]:

> (...) and we try and make clothing that does not look eco or you know recycled, just has a very different image to that. (...) So we try and just steal away from it as much as possible. We definitely do have a lot of shops that really enjoy our story and really enjoy selling that story to their customers. They find it a nice way to engage with people as they're coming to their shop, and suddenly it comes up and they, mainly the sustainable shops actually, rather than the other normal boutiques we sell to."

Upcycler 1 on the other hand communicates the upcycling message very strongly, which to them is not negative. In fact, the textiles are "never identical from one piece to another, they have all kinds of small marks and small little

details, but for us it's part of the identity of the dress. It's not a mistake; it was what the material was like." [U1–96].

Standardisation

An expectation on behalf of retail is standardisation. In the past, when still producing 100 % upcycled textiles, Upcycler 2 was confronted with the problem that their products weren't standardised enough for shops or department stores to buy them, e.g. in terms of colour. They only wanted to buy certain colour combination that they saw and did not understand, that these could not be repeated. As regards the consumer, this might be less of a problem as they can just pick whatever ones they see in a shop. [U2–76]. But in terms of retail this is difficult, because of the competition in the market:

> "If it's you it's not easy to work with, they go to another designer and buy from them instead." [U2–80].

Price

Although competition is fierce, the price of upcycled products was not mentioned as a particular challenge. Both companies serve rather higher-priced segments. Upcycler 2 [14] for example charges about 100 Pound Sterling for a jumper, 200 Pound for a coat.

Quality and **Quantity** have not been mentioned as a particular challenge in distribution. As both companies are very concerned about the quality of their products this might not be an issue (anymore). Quantities might not (yet) be an issue, as the market and the quantities they produce are still rather small.

Upcycling, and especially upcycling from PCTW is partly confronted with negative perceptions by the customers/consumers. This can make it hard to sell "upcycled" as an added value or unique selling proposition (USP), which is especially the case when compared to other sustainable products. Selling the story is however possible, as can be seen in the case of Upcycler 1. Lack of standardisation of PCTW upcycled textiles can be another issue, which can keep mainly retailers from buying upcycled products.

7. Discussion

In this chapter, the results of the empirical study are discussed with regard to their practical and scientific relevance. Section 7.1. critically reflects on the proceeding and presents implications to the scientific community based on the results. Section 7.2. summarises and discusses the empirical results with regard to their relevance for business practice and suggests solution approaches to the most important challenges of upcycling post-consumer textiles from recycling companies on an industrial scale.

7.1. Proceeding and implications for the scientific community

This research project dealt with an issue, that is often neglected by practice and understudied in research. Waste and particularly textile waste does not seem to be a very interesting or relevant topic when concluded from the availability of recent data and literature on textile waste generation, recycling and upcycling. Data on textile waste production in many counties is only available fragmentarily, i.e. for some of the waste streams, and if available, its scope is not sufficiently defined. Data on international levels is scarce while global data on textile waste production lacks entirely. In order to be able to evaluate the situation of textile waste generation and textile waste streams, and to effectively tackle the issues related to it, statistical data should be gathered comprehensively and analysed consistently.

Scientific literature on the industrial textile recycling industry is partly very

outdated, especially in the case of Germany, where available literature is nearly 20 years old. Furthermore, textile recycling literature often describes the supply chain, material streams and especially the issues related to value-oriented recycling only shallowly. As a consequence of lack of valid information on textile waste generation and recycling, the study partly lacks a precise and valid (contemporary) description and evaluation of the situation on the textile recycling industry.

Due to upcycling being a very young approach to sustainable fashion production, there are only very few scientific publications on textile upcycling, all of which deal with the topic primarily from a fashion designer's perspective. Up to now, the concept of upcycling in fashion design, the way it is practiced today, had not been described as a sustainable practice, which is why the term was sometimes used randomly. Within the framework of this thesis, upcycling in fashion design was described as an eco-efficiency-based, primarily value-oriented concept, that represents an alternative approach to waste management according to the waste hierarchy. Although (falsely) referred to by Dunn (2008) and Aus (2011), upcycling, the way it is practiced today, is not a concept of eco-effectiveness. Although this description of upcycling in sustainability terms should be extended and deepened, the foundations to legitimise the concept as a sustainable practice could be laid in this thesis. Furthermore, the techniques used in upcycling were assigned to different forms of recycling, finding that upcycling comprises techniques of product, component and material recycling. Due to the lack of economic literature on upcycling, the upcycling supply chain had to be modelled on the basis of literature on textile production, closed-loop supply chains and available information on upcycling. The potential issues that form part of the theoretical model, partly lack reliable theoretic, particularly scientific foundations. As a result, the development of the theoretical model represents a significant part of the personal contribution of this research project. For this reason and due to the intrinsic complexity of the matter, the theoretical section of this thesis prevails and some of the supply chain phases, namely production, could not be regarded as separate categories. Moreover, the theoretical model had to be designed broadly, i.e. using rather open categories and indicators. Although this poses a risk to gathering and analysing empirical data in a targeted way, due to the high degree of uncertainty this proceeding was deemed necessary. However, when analysing the results, the interdependency of the previously defined success factors became clear, as well as the interrelatedness between the crucial phases of sourcing and designing. Identifying crucial factors and challenges of upcycling might have been easier, if the supply chain of upcycling had already been described.

Due to the complexity of model development, the empirical part of the thesis represents a less focal section. Hence, only three expert interviews were conducted. In general terms it would have enriched the study, if another recycling company could have been interviewed, too. Particularly a smaller recycling company could have posed an interesting counterbalance to the global player who participated.

However, due to the pioneer character of the research, by examining textile upcycling from an economical, supply-chain-based perspective for the first time, the research opens up the field of textile upcycling for further, especially economic research studies. Describing the upcycling supply chain revealed a lack of standardisation of the industrial upcycling process, based on the low degree of standardisation of input material. In order to enable industrial upcycling of post-consumer textiles, further research on suitable waste streams and product categories as well as sales markets for industrially upcycled PCTW products is needed. This includes the development of appropriate upcycling techniques and business models for industrial PCTW upcycling and the development of technologies and processes to further standardise production.

7.2. Results and practical implications

The results have shown that upcycling of PCTW from recycling companies on a larger scale is possible, if materials are mixed with other types of meter fabrics or more standardised textile waste. This strategy to standardise production had not yet been described in literature, However, it backs the conclusion of Dunn (cp. 2008, p. 92) that repeatability of designs is achievable on a larger scale of production with "more standardised raw materials" where she subsequently refers to remainder stock as one suitable raw material type. Fraser's (cp. 2009, p. 54) insight, that upcycling of PCTW offers the potential for producing standardised fashion products, can also be confirmed in that context, as standardisation of production and products (independently from quantities produced) is generally possible. Although the cases investigated mix materials, the fact that they use the same sourcing strategy (specific textiles) as Fraser did justifies this.

The supply chain of industrial textile upcycling as modelled in this thesis on the basis of the empirical study, coincided with the supply chain modelled in the theoretical part of the thesis. In doing so, it also validated the industrial manufacturing process developed by Fraser (cp. 2009, p. 50) and the differences to regular textile production she had identified.

The upcycling supply chain does not specifically refer to post-consumer textile waste, but applies to production and pre-consumer waste as well. Although, the modelling of a generic supply chain of upcycling was not intended, it represents a crucial finding of the research study: it implies that the supply chains for the different types of textile waste do not significantly vary, as had been assumed in the beginning, based on the insights of Aus (2011).[100] As waste materials generally vary to some extent, the supply chain phases are basically the same, only when using production waste, unpicking can be skipped. For the various types of waste they only differ with regard to their complexity or intensity. This means that also production, pre-consumer and post-consumer waste from institutional consumers have to be sorted and sometimes cleaned. The major difference between PCTW from textile recycling companies and all other kinds of textile waste is its low degree of standardisation. Compared to all other types of textile waste, it is the least standardised type and source of waste. Considering the other influencing factors in this study (quality, price, quantity), the non-standardisation of raw materials is the most dominant factor leading to the majority of challenges PCTW upcycling is confronted with. The second most relevant factor is the quality of materials.[101] On top of that, non-standardisation largely affects the available quantities of material. This finding is very well reflected by Aus' (cp. 2011, p. 50) statement that although feasible, post-consumer waste is not easy to use in serial and mass production due to lack of availability in large quantities, insufficient quality and due to having a finished and used garment as a starting point material.

In contrast to what was previously expected based on the findings of Aus (2011), costs or prices do not seem to represent a major issue to any of the actors involved. This might also have changed with the development of upcycling strategies and the increasing standardisation of the process. In fact, savings on raw material costs provide the opportunity to minimise or even balance additional costs of processing which makes upcycling at least a competitive concept of sustainable fashion production. Insofar, upcycling practice is a step ahead of upcycling literature.

100 The only difference between upcycling production, pre-consumer or post-consumer waste is that production waste does not require unpicking. Furthermore, some phases (e.g. sorting) can be more complex in dependency of the type of textile waste.

101 Fraser (cp. 2009, p. 38) had identified the raw materials quality a key parameter for successful upcycling.

In general, when considering the entire supply chain, industrial upcycling is confronted with the following major challenges:

1. Non-standardisation and deterioration of materials affects the motivation of the entire fashion market to get involved in upcycling. On the one hand, upcycled materials sometimes raise negative associations. On the other hand, and also linked to negative perceptions, upcycling does not really provide an added value, another story, compared to other ways of sustainable production. In some cases, especially for PCTW from institutional consumers like for example the military, the history of the garment can be used to create a story, an identity of the textile, to involve the customer. As a marketing instrument, creating an identity underlines the uniqueness of the product which can even be supported by imperfections such as little holes or stains. This identity or "patina" distracts from the fact that the material is used. In best case, creating an identity as a unique selling proposition, can even function as a sales argument. However, in the case of household post-consumer textiles, creating a story around a product is more difficult, due to its ordinary prevalence, but it is still possible and shops can tell a story, as could be seen in one of the cases.

In order to successfully market PCTW upcycled textiles, other marketing and sales strategies might be required. As the example given by the recycling company has shown, working with prominent designers or celebrities in general, can lead to extraordinarily good results and a high demand for upcycled products. Which segment of the fashion market should be served, is a major question in this context. The high-fashion market might be unsuitable, due to the limited amounts of high-quality material that recyclers process and due to the conflicting potential with other business segments. The sustainable fashion market is the most natural option: Retailers and customers still seem to enjoy the story, as upcycling is not yet very common. However, other sales arguments (especially design, quality and price) will have to be considered, and in general, the sustainable textiles market too, is a rather high-priced and still a small market segment. This means that again, expectationson material quality could be too high and potential sales volumes too low in order to make a difference.

Consequently, alternative business models to really start producing on an industrial scale and to be able to supply mass markets, have to be developed. Upcyclers and recyclers are jointly required to look into the recycling waste stream in order to identify abundant, yet still suitable product categories for mass production. Further standardisation of the production process is needed in order to be able to use the price as a major sales argument and to be able to serve less premium-priced segments.

2. As regards the processing within the supply chain, the lack of standardisation, combined with deterioration, leads to a number of consequences: Fundamentally, some of the processing steps become more complex and therefore more time-consuming and expensive, this affects especially sorting and design. As the textiles naturally vary from piece to piece, sorting has to consider more criteria compared to other waste types. Designing from non-standardised materials is more difficult, especially creating repetitive designs. As a result, it is barely possible to produce standardised textiles from 100 % PCTW from recycling companies. Due to this intrinsic disadvantage, industrial upcycling companies do not exclusively use this type of waste in their production, but mixing with either other types of textile waste or meter fabrics, in order to facilitate standardisation of production. Hence, especially for garments, the material is unsuitable as main material.

The strategy of mixing is one of the major strategies industrial upcyclers use, in order to reduce complexity of designing, increase standardisation and facilitate industrial production. In this way, shares of post-consumer material can relatively easily be integrated into otherwise virgin (or recycled) products. When used as supportive materials such as lining, the PCTW can easily have imperfections like e.g. stains, as they would not even be apparent. This strategy could especially be interesting for large fashion brands that, due to lack of experience with the matter or other reasons, up to now refrain from upcycling, as they would not be forced to produce 100 % upcycled garments. The risk connected to this strategy, however, is that the shares of recycled content within textiles might be too low to environmentally really make a difference, and especially to represent an interesting sales market to sorting companies.

Mixing is part of the business model of the upcyclers who participated in this study and is necessary insofar, as both entirely rework the recycled textiles they source. This means that industrial PCTW upcycling, the way it is performed today, represents a component or material-based rather than a product-based recycling strategy. Hence, upcyclers apply the techniques of reconfiguration rather than using reconstruction on product level, combination and embellishment as alternative upcycling techniques. Reconfiguration is the most complex and labour-intense of the upcycling techniques, as the textiles have to be disassembled before a new product can be sewn. Due to it being a labour-intense process, the rationalisation potential of these techniques is limited and with it the potential to achieve economies of scale. Hence, cost degressions can mainly be achieved with regard to managerial or administrative tasks related to the process. The potential could be increased, if upcycling companies could manage to increase the number of pieces per lot and hence be able to achieve quantity discounts on sourcing and production. However, due to the high costs of labour and the labour-intensity of the process, the potential to make use of economies of scale might still be relatively low. On top of that, finding suitable partners for production is hard in upcycling, because the additional steps of the process require specific resources such as skilled labour[102] and appropriate facilities that usual textile production does not require.

Another issue related to reconfiguration is that both techniques usually produce high amounts of waste, as not all parts can be reused. One of the upcycling companies eliminates this issue by having a rather broad product portfolio which allows them to reuse as much of a textile as possible for a number of applications.

In general, mixing with other, more standardised fabric is a very valuable strategy upcyclers developed and only enables large-scale production of upcycled products on material level. The reason is that reconfiguration allows a higher degree of standardisation of the final product and on top of that leaves a higher degree of creativity to the designer respectively fashion brand. There is potential to scale up production using this technique, it would, however, require to source only commonly available product groups and fabrics like e.g. jeans from recyclers, as the availability of PCTW represents the limiting factor in this case.

Although costs respectively prices could not be identified as a particular challenge, being able to further rationalise the process or especially skip some of the additional processing steps required, would decisively support the ability of upcycling entering lower price segments and with this mass markets. The main potential here could be lifted, if ways to reconstruct on product level (without disassembly) or to embellish PCTW could be identified. Reconstruction and embellishing by minimally re-sewing garments or applying decorations, allow skipping disassembly of a finished textile and reducing the effort required to reassemble a product. Furthermore, these processes are not

102 Another key parameter Fraser (cp. 2009, p. 48) had identified is the disassembling expertise.

limited to high-quality fabrics like e.g. reconfiguration is, as the materials are not entirely reworked and therefore do not have to fulfil high standardsregarding fabric strength. This would enable upcyclers to use medium or even low quality textiles that recyclers can supply more easily, as well.
In order to facilitate embellishment/reconfiguration, recycled garments could be combined with virgin fabric, for the purpose of increasing the degree of standardisation, as this seems to be an important criterion for retailers. The combination of various recycled products could be another strategy to minimize efforts, however, due to the non-standardisation of materials, achieving an industrial scale might, again, be hard. Given there are suitable product groups in sufficient amounts, in order to enable embellishment, reconfiguration and combination, the minimal efforts required for production would enable upcycled textiles to achieve low price levels, so they might even be competitive with fast fashion products. Turning low quality, but rather well preserved fast fashion products into new fashionable, upcycled textiles again by applying minor changes, represents an entirely new approach to textile upcycling. The lack of similar initiatives might be based on the fact that upcycling up to now has primarily represented an approach developed, adapted and promoted by designers who preferred to or felt it necessary to entirely rework recycled textiles. But it could also be that minor changes to a garment are insufficient to standardise the output, or do design-wise not look good enough for consumers to be willing to spend a certain amount of money for the garment. Designers, upcyclers, recyclers and fashion industry in general should, however, look into such approaches, in order to find out whether they provide potential to develop feasible and profitable business models.

3. As regards sourcing of materials, the lack of standardisation of PCTW form recycling companies "forces" industrial upcyclers to source only specific types of textiles, in order to be able to produce repetitive designs and in order to generally make designing more independent from sourcing. Although the approach of sourcing specific materials represents a key strategy that only enables industrial upcycling of this type of PCTW, its implications can fundamentally affect the motivation of recycling companies to co-operate with upcyclers. This is based on the fact that upcyclers are primarily quality-oriented when sourcing textiles, whereas recyclers are mainly quantity-oriented when selling textiles. This leads to the conflict of upcyclers mainly sourcing high quality textiles that are only limitedly available. This might lead to shortages of materials supplied for the upcyclers, and insufficient demand for recyclers meaning that the amounts of materials bought are by far too low compared to the overall amounts such companies process. Another conflict resulting from the deviation of orientation is that in demanding high-quality products that are generally in more demand and might be key products to other customers of a sorting company, conflicts with traditional business segments occur. In the worst case, selling to upcyclers what they usually demand messes up the entire business model of a textile recycling company and leads to much more products being downcycled. Due to those issues, classic textile recycling does not consider fashion upcycling a promising sales market.

If fashion upcycling is ever to become an interesting sales market and alternative option to other forms of recycling, the volumes that upcycling companies can process have to increase substantially. Moreover, upcyclers are required to be more co-operative in the choice of materials and more responsive to what recycling companies can offer in certain, high amounts. Hence, close co-operations, or rather strategic partnerships between both types of companies are needed. In order to enable upcycling of large amounts of PCTW from textile recycling companies, the development of different business models might be required, as the existing ones do not yet manage (or even intend) to process

high amounts of post-consumer waste from recycling companies. Recycling companies might lack the motivation to follow up on such options, as their primary concern is to recycle as much as possible and the established recycling system based on the waste hierarchy, is not as easily combinable with an alternative approach to waste management like upcycling reflects it.

8. Summary

In this section, the results of the research project are summed up, and the research questions are answered.

The aim of this thesis is to model the supply chain of industrial upcycling of post-consumer textile waste and to identify challenges along this supply chain that refer to the use of post-consumer textile waste, sourced from industrial textile recycling.

As an additional task within this thesis, the concept of upcycling in fashion design has been embedded into the context of sustainability, by assigning it to one of the sustainability principles and classifying existing upcycling techniques to the various categories of recycling.

Within the framework of this paper, upcycling in fashion design, the way it is practised today, represents a concept of sustainable textile production, based on the sustainability concept of eco-efficiency. As a primarily value-oriented approach, which uses different recycling techniques on product, component or material level, upcycling can be classified as an alternative approach to the prevailing waste management approach reflected by the waste hierarchy.

In the following, the three research questions are answered:

1. *How is the supply chain of industrial upcycling of post-consumer textile waste organised and where does it differ from the production of virgin textiles?*

The supply chain of industrial textile upcycling of PCTW, as identified on the basis of the cases examined, basically coincides with the supply chain of regular textile and garment production. Independently from which type of textile waste is used, it can be considered the supply chain of upcycling. It can be depicted as follows:

* Sourcing includes checking/grading/sorting and storage of material
** Production includes disassembly and reassembly and prior cleaning and colouring if necessary

Fig. 14: The supply chain of industrial upcycling

In some aspects, the supply chain as of upcycling differs from regular textile production. In contrast to the latter, supply and design in industrial upcycling are highly interrelated, i.e. design is always based on the materials and the amounts available. Furthermore, industrial upcycling requires additional processing steps, namely sorting, cleaning and disassembly. Especially sorting and disassembly are non-standard, labour-intense processes that result, in the industrial upcycling process being more costly compared to regular textile production. If production (unpicking, cutting, sewing) is outsourced, partners with specific additional resources (upcycling knowledge and appropriate facilities) are needed.

2. *What are the reasons that hinder industrial upcycling companies from using post-consumer textile waste as raw material for garment production, i.e. what challenges do industrial upcycling companies face due to the fact that they use post-consumer waste from recycling companies?*

Compared to all other types of textile waste, post-consumer waste from textile recycling companies is least standardised. This leads to a number of challenges:

- Sourcing options are limited to materials where high amounts can be provided. This limits the freedom of the designer to work with less common product groups, fabrics or colours.
- As recycling companies are quantity-oriented in selling, large textile recycling companies especially lack interest in selling to upcyclers as they do not source large enough amounts to form an interesting sales market and usually request materials that conflict with other business segments of sorting companies.
- Upcyclers are rather quality-oriented in sourcing. As industrial upcyclers rework the textiles they use and this puts stress on the material, this is also crucial for PCTW upcycling. However, the quality of most PCTW fabric is poor, which limits the amount of available material.
- Designing standardised products is more challenging, due to the varying input material. As a result, producing high amounts of standardised textiles from 100 % PCTW sourced from recyclers is barely possible, the material has to be mixed with other, more standardised raw material. For the same reason, the textiles are rather suitable as supporting or decorative material, than for use as main material.
- Processing is only limitedly standardisable and therefore more costly. Because of every individual textile being different, sorting the materials becomes more complex. Furthermore, post-consumer waste has to be individually unpicked and cut before it can be sewn.
- For cutting to be outsourced, partners require specific resources (knowledge and facilities) that usual textile production does not require.
- Upcycling is considered a form of sustainable fashion production. As there is no individual market segment for upcycled textiles within this market and no clear or particularly positive unique selling proposition (see also the following challenge), they directly compete with other sustainable textile products.
- Upcycled, or recycled materials in general, are sometimes perceived as "dirty".
- Retailers require highly standardised products. They are not willing to accept larger variations in colour for example. Due to the fact that the material naturally varies, this is only achievable by sourcing specific textiles.

"Industrial" upcycling today represents a semi-standardised and -industrialised practice, something in between of high fashion and mass-production: Industrial upcyclers (upcyclers in general) usually demand high-quality fabrics from sorting companies, as they rework the fabrics, which is why a fabric has to be of sufficient strength. Due to the lack of large amounts of standardised high-quality textiles and using reconfiguration/reconstruction techniques, sourcing volumes are too low, production capacity is limited and the process is labour-intense.

3. *What potential solution approaches could improve the co-operation between industrial upcyclers and industrial textile recyclers?*

If fashion upcycling of PCTW is ever to become an upcycling technique on an industrial scale, the pre-requisite is to identify suitable product groups that allow scaling up of sourcing and production capacities, from where we stand today. This is something upcyclers, especially designers, and recyclers can only achieve by co-operating more closely by figuring out how the requirements that were identified in this thesis on behalf of both companies can be transferred to upcycling practice. Putting industrial upcycling of PCTW into practice might require the adaptation of existing business models on behalf of upcycling companies. Apart from using different types of materials from what they are sourcing now, this might also require to develop new business models, that are more suitable to what textile waste recycling companies can provide.

The majority of fabrics they process are not high-quality fabrics, which disqualifies them as material for being reworked entirely, i.e. reconfigured. The most natural option in this case is to investigate on how techniques of reconfiguration, embellishment and combination could be used in industrial upcycling. These are techniques of product recycling, hence they do not necessarily require a deconstruction which makes the designer become more independent from the quality of the fabric. At the same time, processing costs could be reduced, as unpicking, cutting and sewing would be minimised. As a result, larger amounts of textile waste could be processed, the generation of textile waste could be reduced and higher amounts of products could be produced. In that way, upcycling of PCTW from recycling companies could be lifted to an industrial scale and based on available demand, mass markets and lower price segments could be entered. Whether creating a sufficiently high demand for such types of upcycled textiles, specifically garments, is feasible will be largely dependent on the marketing strategy used. In case sourcing and processing costs can be sufficiently minimised with this strategy, an attractive price of such textiles can function as a strong sales argument. However, due to the partly negative associations linked to upcycled textiles, they might not provide a sales argument in themselves by the story they tell. Furthermore, the major challenge regarding this strategy, will be to standardise products sufficiently, e.g. in terms of colours or shape, for retailers/customers to demand those products. This would require to focus on other ways of marketing upcycled textiles, like creating a strong brand, by working e.g. with celebrities who can transfer a positive image to recycled products.

In conclusion, the paper identified the supply chain of textile upcycling and challenges linked to the upcycling of PCTW from industrial textile recycling. With this, the basic adjusting screws for process optimisation and the development of new, suitable and scalable business models for industrial upcycling of post-consumer textiles could be laid. Whether or not this thoroughly environmentally-friendly approach provides a solution to effectively tackle the issues of textiles and textile waste production, depends on the upcycling and recycling industry and their creativity and willingness to further elaborate on the concept. To initiate this process, this thesis can provide the fundament. Or to conclude with the words of James Russell Lowell (2014): "Creativity is not the finding of a thing, but the making something out of it after it is found."

Annex 1 - Interview Guidelines

a) ***Guideline for upcycling companies: Upcycler 1***

Introduction

Private households are the largest producers of textile waste in the European Union. A large fraction of these textiles ends up in incineration plants or is dumped on landfills, while another huge fraction is collected by textile recycling companies and subsequently resold, or downcycled to insulation or filling material.
This thesis raises the question why only few industrial upcycling companies source textile waste from (second hand) textile recycling companies?
Thus the with *aim of the master thesis* is to describe the reasons why industrial upcycling companies do not consider recycling companies as preferred partners, and to depict potential solutions to promote the co-operation with second hand companies.
The *aim of the interview* is to identify the hindrances in working with textile waste as a resource, i.e. in contrast to usual garment production, and why post-consumer waste from recycling banks is not considered a preferred input material.

Interview guideline

1. Upcycling has become increasingly popular in recent years. Some people think it is more than a fashion trend: it will change the way we produce and consume textiles. Others say upcycling will always remain a niche market. What do you think?

The supply chain of upcycling.

2. Talking about the process of upcycling: Using the example of a new garment collection, how do you proceed from the initial step to the final product?
3. Where does the process of upcycling differ from regular garment production? What consequences does this have?
4. If you look at the entire process of upcycling, is there any crucial factor(s) that determine(s) the success of upcycling textiles?

Using waste as an input. Using second hand materials.

5. Why do designers decide to work with waste as an input material?
6. From Somewhere, Worn Again, Raeburn also successfully upcycle on an industrial scale. None of them works with second hand recycling companies. What so you think are the reasons?
7. You also work with textiles from recycling banks (products that have been used before). Why do you source recycled textiles there?
8. On the website it is written that in the beginning [company name] only used *used products*?
9. Recently you began using virgin materials as well. What are the reasons behind this decision?

To conclude

1. For the future: In order to have more upcycling companies processing in series from post-consumer waste. What do you think has to change?

b) ***Guideline for upcycling companies: Upcycler 2***

Introduction

Private households are the largest producers of textile waste in the European Union. A large fraction of these textiles ends up in incineration plants or is dumped on landfills, while another huge fraction is collected by textile recycling companies and subsequently resold, or downcycled to insulation or filling material.
This thesis raises the question why only few industrial upcycling companies source textile waste from (second hand) textile recycling companies?
Thus the with *aim of the master thesis* is to describe the reasons why industrial upcycling companies do not consider recycling companies as preferred partners, and to depict potential solutions to promote the co-operation with second hand companies.
The *aim of the interview* is to identify the hindrances in working with textile waste as a resource, i.e. in contrast to usual garment production, and why post-consumer waste from recycling banks is not considered a preferred input material.

Interview guideline

2. Upcycling has become increasingly popular in recent years. Some people think it is more than a fashion trend: it will change the way we

produce and consume textiles. Others say upcycling will always remain a niche market. What do you think?

The supply chain of upcycling.

3. Talking about the process of upcycling: Using the example of a new garment collection, how do you proceed from the initial step to the final product?
4. Where does the process of upcycling differ from regular garment production? What consequences does this have?
5. If you look at the entire process of upcycling, is there any crucial factor(s) that determine(s) the success of upcycling textiles?

Using waste as an input. Using second hand materials.

6. Why do designers decide to work with waste as an input material?
7. I read you work a lot with textiles from recycling banks (products that have been used before). Why do you source recycled textiles there?
8. From Somewhere, Worn Again, Raeburn also successfully upcycle on an industrial scale. None of them works with second hand recycling companies. What so you think are the reasons?

To conclude

9. In an interview you once said that in the beginning you made 100 % upcycled garments, but you just couldn't keep the quality and standardize it enough for shops wanting to buy the same colour combinations in a good size break down. What is it that has to change that you could produce 100% upcycled garments?

c) Memory Minutes - Interview 2, October 4th, 2013

Answers to t guideline according to questions and categories of analysis

1. Upcycling has become increasingly popular in recent years. Some people think it is more than a fashion trend: it will change the way we produce and consume textiles. Others say upcycling will always remain a niche market. What do you think?
   - Upcycling is performed for more than 10 years already, however it is astonishing what happened in the last decade. Still it is a very small branch in fashion design. she sold 600 pieces with her last collection. For the next 50 years she thinks there is great potential for the concept to further develop

2. Talking about the process of upcycling: Using the example of a new garment collection, how do you proceed from the initial step to the final product?
   - She uses always the same materials and colours(aran jumpers, wool, silk if available; black, blue grey) from textile recycling companies, thus a collection can be designed before sourcing
   - The materials the textile recycling companies sort are stored there, but have to be sorted again by [name of upcycler 2] before being bought and taken. Although sorter sorts according toher wishes, the materials do not entirely fulfill [name of upcycler 2]'s requirements.
   - The garments are then sent to Bulgaria where they are processed: cut and sewn

3. Where does the process of upcycling differ from regular garment production? What consequences does this bring?
   - upcycling is more expensive resp. less competitive to virgin in general due to:
   - Several (extra) manual working steps (sorting and grading, washing(?)
   - Input material differ: colours, fabric material, fit, sizes) so the process can not as easily be standardized/ only standardized to a certain degree.
   - Amounts of material processed are still small due to low demand and limited availability of input material
   - She tries to use as much recycled as possible, but 100% recycled is barely possible on a large scale, due to the lack of standardized materials
   - Currently she only makes one collection per year, in the past two per year

4. If you look at the entire process of upcycling, is there any crucial factor(s) that determine(s) the success of upcycling textiles?
   - design/consumers:
     - people will buy it because it looks good, thus design is central for distribution.
     - recycled/upcycled does not seem to be a sales argument -> people who are not into fashion/sustainability/upcycling initially have negative associations, and think the clothing will look unattractive, if they see it then they are surprised

    - upcycled clothing is often poorly designed which partly explains its image not being the best
- design: strategy to mix virgin with recycled, this enables producing larger batches and thus also enables her to absolutely process a larger amount of recycled material
- quality of material is important as using low-quality items would not be worth the effort. most of the textiles from recycling companies is low quality, but there are also a lot of good quality (potentially usable) textiles

5. Why do designers decide to work with waste as an input material?
    - Working with waste is an ideological, sustainability based decision as it makes the process of designing harder.
    - It is also a personal challenge
6. Talking specifically about upcycling second hand materials now. I read you work a lot with textiles from recycling banks (products that have been used before). Why do you source material there?
    - She uses the material for environmental reasons as to her it is the most sustainable fabric: it is there already, there are no further advantages.
    - [name of upcycler 2] co-operates with two recycling companies they have a good relationship with
    - For both of them the co-operation is not easy: what the sorters sort out for [name of upcycler 2] has to be sorted again before being bought. They work on improving it, but the continuous collaboration is based on their good relationship
    - The size of the textile recycling company has to fit with the amounts that she can use from them, she had a talk with someone from [Name of recycling company], but as they process such huge amounts a co-operation with such a small company as [name of upcycler 2] is not interesting to them

7. From Somewhere, Worn Again, Raeburn also successfully upcycle on an industrial scale. None of them works with second hand recycling companies. What do you think are the reasons?
    - Upcycling post-consumer waste does not offer any real advantages, designers like her decide for working with this kind of waste for ideological reasons. To her it is the most sustainable fabric, as it is there (does not have to be produced).
    - Compared to pre-consumer waste she says that co-operations with brands is not yet easy: Corporations are interested and aware of the problems, but still sceptical about the quality and potential of upcycling.
    - Besides pre-consumer waste producers have a very complex supply chain and are often not yet aware where waste occurs and in what quantities. Furthermore they have a range of options to dispose of their material (besides destruction and incineration/land filling selling to markets they normally don't operate in.

8. In an interview you once said that in the beginning you made 100 % upcycled garments, but you just couldn't keep the quality and standardize it enough for shops wanting to buy the same colour combinations in a good size break down. What is it that has to change that you could produce 100% upcycled garments?
    - Customers are not willing to accept variations of colour or size, they want standardized products, they see something and want exactly that product. They want easy decisions.
    - They do not understand if one specific product cannot be supplied in e.g. their size
    - wholesale/retail arguments the same way, she has to explain to them and they become more tolerant, but this is hard work

9. Who buys upcycled clothing?
    - Most people buy it due to the design, it has to look good. for no environmental reason
    - Some people also see the "recycled" aspect as a feature worth talking about
    - Generally she says there is no typical buyer of upcycled garments

10. Would somebody who buys upcycled garments want upcycled medium or low quality garments at all?
    - It would make no sense in producing upcycled garments from fast fashion/low quality items as it would not be worth the effort.
    - If low quality products were used she could not secure a sufficiently

high quality and upcycled garments are produced with the intention to last

d) ***Guideline for recycling company***

Einleitung

Diese Thesis behandelt die Frage, warum nur sehr wenige der industriellen Upcycling-Unternehmen Altkleider (post-consumer textiles) von Textilrecyclern als Rohstoff für ihre Produktion verwenden und erforscht die zugrundeliegenden Ursachen.
Ziel der Masterthesis ist es, Schwierigkeiten entlang der Wertschöpfungskette des Upcycling zu identifizieren, die Gründe für den Mangel an Kooperation zwischen Upcycling- und Recycling-Unternehmen zu identifizieren und Lösungsvorschläge für die Zusammenarbeit beider Parteien zu erarbeiten.
Ziel der Interviews ist es, die Gründe beider Parteien zu identifizieren, die aktuell einer Kooperation zwischen Industriellem Upcycling und industriellem Downcycling verhindern.

Interview Leitfaden Textilrecycler

10. Der Altkleidermarkt hat sich in den letzten Jahren zunehmend verändert. Viele Textilrecycler beklagen den verstärkten Wettbewerb und die geminderte Qualität der Sammelware. Wie siehst Du diese Entwicklung?

Recycling

11. Welche Arten von Textilmüll verarbeitet [Firmenname] neben Alttextilien (z.B. Produktionsabfälle, Verkaufsreste)? welches sind die größten Fraktionen?

Recycling & Upcycling

12. Ist das Thema Upcycling für [Firmenname] im Allgemeinen interessant? Welche Potentiale siehst du hier für Textilrecycling-Unternehmen?
13. Gibt es bestehende Kooperationen mit Upcycling Unternehmen? Wenn nicht, warum?

Wenn nicht schon im Rahmen von 4. beantwortet:

Anforderungen

14. Welche Bedingungen stellt ein Textilrecycler wie [Firmenname] an eine Kooperation mit einem Upcycler bzw. Einem Kunden generell?
15. Upcycling Unternehmen verwenden meist spezifische Altkleider, z.B. Jeans oder Lederjacken. Diese müssen darüber hinaus weitere Kriterien wie Art des Materials und Qualität, Farbe erfüllen. Ist die Bereitstellung großer Mengen solcher Materialien überhaupt möglich? (verfügbare Menge, verfügbare Qualität, Prozesskompatibilität).
16. Seitens der Upcycling-Unternehmen wird in erster Linie die minderwertige Qualität der Materialien als Grund dafür genannt, dass diese nur beschränkt mit Textilrecyclern zusammenarbeiten. Ist die Qualität der Altkleider (Material, Verarbeitung, Verschmutzungsgrad) im Durchschnitt tatsächlich nicht zur Herstellung neuer Kleidung geeignet? Unterscheidet sich das für die unterschiedlichen Märkte, in denen [Firmenname] operiert?

Schließlich

17. Um die Kooperation zwischen Recycler und Upcycler zu vereinfachen: Welche Veränderungen im Textil- bzw Alttextilmarkt wären nötig? Was würdest du von den Upcyclern erwarten?

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